

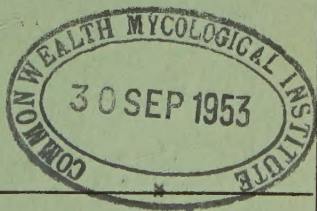
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Autumn 1953



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ARTICLES

WILD OATS

C. V. DADD

National Agricultural Advisory Service, Eastern Province

Old aches and pains sometimes come to be accepted as inevitable : but when the pain spreads to another limb, complaint is heard and an effort is made to cure the whole condition. So it is with wild oats. The species is far from new as a weed in this country, and has come to be accepted, along with many others, as an unavoidable nuisance in many areas. Recently, however, the spread of the species to fresh parts of the country, coupled with the general interest in weed control, has caused many inquiries as to how eradication or control can be achieved.

The situation in this country is complicated by the rapid spread of a species, only recently introduced, which has slightly different growth habits to the " older " wild oat, *Avena fatua*. The newer one is *Avena ludoviciana*. The two vary, however, in several ways, and the following description of their main characteristics, together with the illustrations on p. 1 of the art inset, will help in identifying them.

Identifying the Species

The grain of *Avena fatua* may be any colour from yellow to dark brown ; the yellow grains are usually relatively hairless, and the dark brown usually very hairy. All seeds have an abscission scar at the base, where they are attached to the panicle in the case of the primary seed, or to the primary or second seed in the case of the second or third seed respectively. All the seeds fall independently as they ripen, and all are awned.

It is not possible to distinguish brown *A. fatua* seeds from brown *A. ludoviciana* seeds on colour alone.

With *Avena ludoviciana* the grain is very hairy, generally larger than that of *A. fatua*, and usually dark brown in colour. Grey seeds have been recorded from several areas, and, on rare occasions, yellow or albino seeds. Hairless seeds have also been reported. The primary grain is attached to the panicle by an abscission scar but the secondary and the tertiary seeds terminate in stalks (not scars as in *A. fatua*). The seeds of the cluster ripen and fall together. The third seed, when it occurs, is awnless.

There is no clear-cut distinction between the species in the vegetative stage—nor is there any reliable way of distinguishing them from cultivated oats in that stage.

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The following table summarizes in a convenient form some of the main characteristics of the two species.

Character	<i>Avena fatua</i>	<i>Avena ludoviciana</i>
Shedding of ripe seeds	Seeds fall separately.	Seeds of spikelet fall together. Force necessary to separate them.
Abscission scar	At base of every seed.	At base of first seed only (second and third seeds end in stalk).
Seeds per spikelet	2 or 3.	2 or 3.
Awn on third seed	Yes.	No.
Approximate seed size (including husk but excluding awn)	First— 16×2.5 mm. Second— 12×1.5 mm. Third— 8.5×1 mm.	First— 18×3 mm. Second— 16×2.5 mm. Third— 9×1.5 mm.
Colour and hairiness of husk	Cream, yellow, light or dark grey, medium or very dark brown. Hairy, moderately hairy, hairless. Any combination of colour and hairiness. Hairs silver or gold. Husk of second seed less hairy than first. Third seed hairless.	Usually dark brown, very hairy. Hairs brown. Third seed hairless. A less common type with grey, very hairy husks may be a sort of <i>A. ludoviciana</i> . Other colours and almost hairless husks known, but rare.
Hairs around callus	Always present. Long or short, silver or gold.	Long hairs always present. Dark on brown and on most grey husks.
Season of germination	A few in autumn, usually Sept.-Oct. Most in spring, usually Mar.-Apr.	Winter, usually late Oct.-early March.
Colour of coleoptile and emerging first leaf	Usually green. Buff or purplish in some strains.	Reddish-brown, buff or purplish.
Hairs on leaf sheath	Individual plants vary from none to very hairy.	Always very hairy.
Habit at maximum tillering stage (not shown when crowded)	Shoots few and erect as in a spring cereal.	Shoots many, forming flat rosette (as in a winter cereal) when given room to spread.
Ears	Symmetrical open panicles on long pliable stalks.	Symmetrical open panicles on long pliable stalks.

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The Bristle-pointed oat, *Avena strigosa*, should not be confused with the wild oats since its seeds are non-dormant and it does not become a weed. Its occasional occurrence may be due to the fact that it used to be grown extensively in England and is still cultivated in parts of Wales and Scotland and in dredge corn in south-west Cornwall. The tip of the husk terminates in two long bristles which distinguish it from other wild and cultivated oats.

It is unfortunate that so far we have only one name (Wild Oat) to describe both species. It is now suggested that a distinction be made to avoid constant reference to Latin names. It would be logical to use such names as "Spring Wild Oat" for *Avena fatua*, and "Winter Wild Oat" for *Avena ludoviciana*.

The seed coat of *A. fatua* is not important agriculturally but can be described when necessary, so also can the seed colour of *A. ludoviciana* (i.e., brown or grey). The chief recognizable difference between the two types of *A. ludoviciana* is in the time between germination to earing, but relatively little investigation has been made so far into the other field characters of the grey kind.

Distribution and Intensity

A joint N.A.A.S.-Rothamsted survey of wild oats throughout the country, which took place in 1951, gave the first accurate picture of the distribution of the species. It would appear from this investigation that the area infested by *A. ludoviciana* has its centre near Oxford, and stretches roughly in a circle of radius 80 miles to the borders of the Eastern Province, along the north bank of the Thames, throughout much of the south of England, up through Somerset and Warwickshire, and to the borders of Lincolnshire. *A. fatua* is far more widespread and is a serious pest particularly in the Eastern Province and parts of the south, and especially in the grain-growing areas of England. Its range, as shown by the 1951 survey, extends from Berwick in the north, down the east side of the country between the Pennines and the coast, across the Midlands as far as the eastern borders of Derbyshire and Staffordshire, and into Shropshire and Herefordshire. It covers all southern England east of a line from Porlock (Somerset) to Totnes (Devon). Wales seems free of wild oats except for a small area of *A. fatua* east of Newport, Monmouthshire. The full report of this survey has yet to be published.

It is only too apparent from the survey that many fields are so badly affected by wild oats that the infestation can be described as intense and far beyond the possibilities of hand pulling. Unfortunately, the investigation did not give any information as to how many fields in any particular area were infested. It was hoped to collect information on this point during 1952, but for various reasons it was possible to do it only on a limited scale. Nevertheless, a "roadside" survey was made, and this assessed the position sufficiently to act as a guide for the

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collection of data in the future.* Nearly 500 roadside fields in the Eastern Province were examined and were classified as having a "high infestation"—where hand pulling was regarded as being impossible—or as having a "slight infestation"—in which case hand pulling was considered to be a practicable method of removal. Excluding oat crops for obvious reasons, it was found that 29 per cent of all winter-sown cereals and 12 per cent of spring cereals carried an intense infestation. This evidence suggests that the wild oat problem is even more severe (or, at least, was in 1952) than is commonly believed, and that a more accurate assessment is justified.

The Spread

It is well known that the spread of the weed from field to field and farm to farm can only take place by seed. Whilst it is possible for seed to be transported in a variety of ways, it is generally accepted that by far the most important method is as an impurity in cereal seeds. Emphasis is added to this point when it is found that wild oats constitute one of the most common reasons for the refusal of certificates in the Field Approval Scheme for cereals. It is vividly illustrated by the following figures from the results of check inspections under the scheme :

			<i>Refusals Expressed as Percentage of Total Acreage</i>	<i>Total Percentage of Refusals Due to Wild Oats</i>
1949	..	..	40	73
1950	..	..	57	53
1951	..	..	58	32
1952	..	..	61	25

Any policy of control must start with the limitation of spread of the weed, and seed should always be examined with this point in mind—it is surprising how many people can overlook wild oat seeds in oats, and even in wheat and barley, if they are only present in small amounts. An experienced firm has stated that it is relatively easy to remove wild oats from wheat over a suitable cylinder ; it is possible to remove them from barley over a separator—although it may be necessary to put the seed over twice—and occasionally with the help of a cylinder ; but that it is impossible to remove them commercially from oats other than by hand picking. It is realized that suitable seed-cleaning equipment is not always available. Nevertheless, it must be emphasized that lasting control of wild oats will never be possible while the seeds continue to be sown.

* In 1953 the roadside survey was repeated on a slightly larger scale ; 28 per cent of winter-sown cereals and 26 per cent of the spring-sown crops were severely infested with wild oats. The increased intensity of wild oats in spring cereals is probably due to the very early sowing possible in the spring of 1953.

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Research and Control

At the present time there does not appear to be any promising selective chemical control which will help very much with this problem. It is known that both propham (IPC)* and dinoseb (DNBP)† are toxic to wild oats, and, if sprayed in a crop such as peas, will sometimes reduce an infestation ; but it is in cereals that the major problem lies, and here, of course, these products cannot be used.

Some may remember the experiments of spraying linseed with a special oil, which had some success in controlling wild oats. Unfortunately, any application of this work is likely to be limited, since it would be difficult to persuade many farmers to sow linseed just for the possibility of killing wild oats in the crop ! The prospects of obtaining a selective chemical control in cereals are not great : the similarities between any of the cultivated cereals and the wild oats, morphologically and physiologically, are greater than the differences.

Research in this country is being carried out at Rothamsted, and is aimed chiefly at determining the fundamentals of the growth of the species, such as seed viability, dormancy factors, etc. Much progress has been made, but a great deal remains to be done.

Field Characters

The two species of wild oats behave very differently in the field. Careful observation on the farm and in pot-scale work shows that while *A. fatua* can germinate at any time during the year, there are distinct "peaks" which occur in spring and autumn, the larger being in spring. In practice, germination in July, August, November, December and January can be ignored. In contrast, *A. ludoviciana* will normally germinate only during the winter, starting sometime during October and finishing in March, that is, between the autumn and spring peaks of *A. fatua*.

With both species, seedlings can emerge from seeds germinating at considerable depths. *A. fatua* seedlings can come from as deep as 7 inches, and *A. ludoviciana* plants from even lower down, some of the latter type having been known to emerge from seeds germinating 9 inches deep.

Evidence is still needed about dormancy and seed survival, particularly about the dormancy of *A. ludoviciana*, but any plan of control must take them into account.

The dormancy of a seed is conditioned by certain factors, that is, certain physical or physiological conditions have to be met before the seed can germinate—assuming it is still viable. In the case of *A. fatua*, there appears to be only one major factor, commonly termed "seed coat dormancy". It has been found that if the seed coat is fractured in any way so as to allow the entry of oxygen to the seed itself, then the seed can be made to germinate as readily as any "ordinary" seed.

* isopropyl-n-phenylcarbamate † dinitro-butylphenol

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Rothamsted work has, in fact, confirmed that cultivation stimulates the germination of *A. fatua*. Unfortunately, it seems that the same is not true of *A. ludoviciana*. The fracturing of the seed coat still has to take place, but this is insufficient to ensure that germination will take place. A further dormancy factor is involved, and, although the details have still to be confirmed, it seems very possible that the second factor is connected with temperature or a sequence of temperature changes.

It has also been observed in the field and in the laboratory that the primary seed of *A. ludoviciana* will germinate more readily than the secondary seed.

Any question on the length of survival of seed buried in the soil will usually produce answers from farmers and countrymen which vary from "a long time" up to "40 years or more". Fortunately, reliable evidence on this important matter is slowly becoming available. It seems that the life of *A. ludoviciana* may be less than that of *A. fatua*—possibly no more than two years, as compared with about four for *A. fatua* in frequently cultivated soil, but confirmation is needed from current experiments. A possible reason for the shorter survival of *A. ludoviciana* is that its primary seeds seem to have relatively little *natural* dormancy. This does not take into account secondary dormancy induced by environment (namely, unfavourable temperature), and recent research suggests that this may be very important on occasions. There is no critical evidence available to support any longer survival, but circumstantial field evidence does suggest the possibility of it, as is illustrated by the germination of seeds which are ploughed up from a depth, presumably having fallen down a crack in the soil and remained deeply buried for a number of years. However, it does seem that the possibility of the survival of *A. fatua* in *frequently cultivated soil* beyond three years—certainly beyond four—is very slight. This gives a useful guide in the planning of cropping and cultivation sequences so as to reduce a field infestation.

Studies on the growth of the species show that flowering in wild oats may take place for as long as six weeks in any one crop. Each seed of *A. fatua* falls as it ripens, while the seeds of *A. ludoviciana* fall in pairs (or clusters of three where the third seed is formed). Only after threshing will the "seed clusters" of this species be broken up, and even then many may survive unbroken but without awns.

It seems that wild oats are broadly similar to *A. sativa* in their tolerance to acid soil conditions. They are recorded as having grown in soil having as low a pH as 4.5, but were more numerous at pH 5.1 and very plentiful at pH 5.8.

Studies have been made on the growth of wild oats in manganese-deficient (peat) soil in comparison with cultivated varieties. The most obvious difference lies in the leaf symptoms. *A. fatua* shows the typical "grey speck" symptoms which are associated with *A. sativa*;

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A. ludoviciana, however, shows white interveinal leaf stripes. The growth of the two species as compared with cultivated oats varies in respect of the factor being studied (seed weight, seed number, plant weight, etc.) but the investigation tended to emphasize the general similarities rather than the differences between cultivated and wild oats.

Methods of Control

The knowledge now being gained of the behaviour of the wild oat species is of considerable value in planning cultural methods of control. The absence of promising chemical methods at present should emphasize the need for careful study of these cultural methods.

So far as one can generalize at all on this matter, the scheme of control may be summarized as follows. First, the utmost care must be taken to avoid the introduction of wild oat seeds into a field. Second, the number of viable seeds in the soil should be reduced by following a rotation (and cultivation) which kills the maximum number of seedlings, and which prevents seeding taking place for at least three or four years. Third, when the plant numbers in the field permit, seeding plants which have escaped previous control methods should be removed by hand. Incidentally, it has been reported that seeds of *Avena fatua* have withstood high temperatures (105°C for 15 minutes being needed to kill them), so stubble burning is unlikely to kill many fallen seeds.

The rotation chosen will obviously depend on whether any amount of *A. ludoviciana* is present—remembering that the major spring peak of *A. fatua* emergence is after the former has virtually ceased—but a crop of late-sown barley, taken after good spring cultivations, can reduce an infestation very markedly.

Successful field experience in wild oat control is limited and it remains to be seen whether complete eradication is economically possible. Furthermore, much has yet to be learned about the behaviour of the seed in the soil, and possible methods of breaking dormancy. The findings of recent research which have very briefly been reviewed here at least point towards some promising methods in the control of a serious weed problem.

Acknowledgment is made to Miss J. M. Thurston of Rothamsted Experimental Station for checking the information in this article, and for the supply of certain factual data.

CORRECTION

N.A.A.S. Quarterly Review No. 19, page 311: Dairy Bacteriology.

The article "Rejection Tests for Raw Milk" by L. F. L. Clegg mentioned on lines 4 and 5, appears in Vol. 14, pp. 731-50 of *Dairy Sci. Abstr.* and not in Vol. 10, p. 732 as stated.

HETEROSIS IN LIVESTOCK

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The gulf between theory and practice of animal breeding is well illustrated by the non-identical twin conceptions of hybrid vigour and heterosis. Hybrid vigour is now mainly a livestock farmer's term and seems usually to mean that a cross-bred is a better animal in some ways than its parents. From a farmer's point of view, the thing is obvious—cross-bred sheep, pigs, beef cattle and hens have well established merits (although, oddly enough, cross-bred dogs and dairy cattle are often supposed not to share them).

Text-books on agriculture have been rather brief on the subject of hybrid vigour. One well-known book on the science and practice of British farming has put it thus: "Cross-bred animals commonly show the phenomenon of heterosis or hybrid vigour—that is to say, are more prolific and more resistant to disease and grow more rapidly than pure-breds". Suddenly cautious, the book does not present any justification for this statement or give any instructions about the best breeds to cross. There is little doubt, however, among either farmers or geneticists, that even if the statement is not always wholly true, it is, like the curate's egg, good in parts, and it does sum up popular notions on the subject of hybrid vigour.

Geneticists rarely use the expression "hybrid vigour"—it is altogether too vague a concept. It has little to do with hybrids (which are crosses between species or genera) and it comprehends a variety of phenomena. Crossing has a value in turning sex-linkage to account in poultry, in grading up, in establishing new breeds and in utilizing to advantage a supply of relatively cheap breeding females; but these functions overlay and confuse the original concept of hybrid vigour. This restricted concept, considerably developed, is called in genetical language "heterosis". Under the circumstances, a writer has an obligation to make it clear what he is writing about. This article is about heterosis—its nature, and its relation to various systems of breeding.

Definition of Heterosis

In an attempt to begin at a point where there seems to be a fair measure of agreement, heterosis may be defined as a positive or negative deviation of any character from an expected value. The significant word is "expected". If it is assumed that the performances of the progeny of a given type of mating will fall midway between those of the parents, then that is the expected result. In matings within a breed, this is the usual assumption. Dairy bulls, for instance, which have daughters averaging 850 gallons out of dams averaging 800

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gallons, would be assessed at 900 gallons themselves. In a breed cross, representative bulls with a breed average of 900 gallons, mated to representative cows of another breed kept under similar conditions and with an average of 800 gallons, would likewise be expected to have daughters yielding 850 gallons. Actual average yields significantly in excess of 850 gallons proclaim positive heterosis, and average yields falling short of 850 gallons, negative heterosis. The idea of hybrid vigour does not embrace negative heterosis.

Some authorities limit the conception of heterosis to performances in excess of the "better" parental type. The expectation, which is then exceeded, is that the progeny will not surpass the better parental type. In terms of a very simple model, the position may be put thus : where the gene combination AA gives a 10 per cent better result than aa , then, in the absence of heterosis and assuming gene effects are additive, the expected result is that the heterozygote Aa would be 5 per cent better than the homozygote aa . Heterosis would be implied by an improvement of more than 5 per cent on aa if the first conception holds, but by an improvement of more than 10 per cent if the second holds.

If gene effects are often non-additive, then heterosis must condition the results of all matings involving many gene differences—which would include those occurring within a breed. Non-additive relations between genes may involve pairs which are not allelomorphic (epistasis) as well as pairs which are (dominance), but the relative importance of these two possible sources of heterosis is still obscure. From the producer's point of view, what matters is whether the net effect of the heterotic deviations of all relevant genes is big enough to make cross-breeding a better proposition than pure-breeding. This kind of question applies mainly to pigs, poultry and dairy cattle, the various breeds of which are kept under similar conditions for similar purposes. For sheep and beef cattle, the question of heterosis is confounded with other functions of cross-breeding such as the utilization of cast ewes from hill flocks.

Experimental Work

As an illustration of circumstances probably to be explained by heterosis, some data on pigs from South Africa may be quoted (F. N. Bonsma and D. M. Joubert, *Bulletin 322*, Department of Agriculture, South Africa). The experimental herd contained pure-bred Large Whites and Large Blacks and the reciprocal crosses.

The cross-bred litters were superior to the pure-bred on both counts, and most breeders would attribute this to hybrid vigour. On the figures so far revealed, however, heterosis cannot be established. There is nothing to show how the cross-breds compared with the pure-bred Large Whites grown under the same conditions. The figures for the Large Black and the Large White sows are as follows :

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Large Black Sows

	L.W. Boar	L.B. Boar
No. of pigs born	10.20	9.47
No. of pigs weaned	7.70	6.03

Large White Sows

	L.B. Boar	L.W. Boar
No. of pigs born	11.66	10.67
No. of pigs weaned	7.80	6.12

Again, the cross-breds were superior on both counts. The expectation that they would fall between the parental levels or even equal the better parent is falsified by the outcome, and an explanation in terms of heterosis is called for.

There is surprisingly little satisfactory information about the magnitude of heterosis in breed crosses—so little that it is impossible to specify unequivocally what breeds ought to be crossed just to exploit it. Evidence has been produced, from time to time, of heterosis in the growth of cross-bred pigs, showing that the cross-breds exceed even the faster-growing parent breed, but this is hardly enough. Reports have also been published giving results of trials showing no heterosis. Apart from questions of breed sampling, there is the possibility that some crosses show it and others do not; in which case, only a long period of trial and error would clear up the position. Proper tests are not easily made. The heterosis is likely to be of a very moderate degree, so that considerable numbers of animals would be needed for its demonstration. Nevertheless, the results of much diverse research indicate that heterosis is not to be ignored because its theoretical foundations are insecure and its study difficult. Practice (on this particular issue) is still in advance of theory, but will not remain so.

Indiscriminate Crossing

An aspect of cross-breeding that deserves a passing word is “indiscriminate crossing”. What is indiscriminate crossing and what are the consequences? By implication, for it is rarely defined, indiscriminate crossing occurs whenever a breeder deviates, without expert sanction, so to speak, from some recognized system. Without going into the question of who the experts are and what systems they recognize, it is easy to see why their disapproval is ineffective. A breeder of beef cattle who rang the changes on several breeds of bull on a motley

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herd of cows might easily be as well off, if not better off, when it came to financial returns, as one of equal skill and opportunity who confined himself to a pure breed. A dairy farmer working on similar lines with dual-purpose breeds could well be in a similar case. Where he may meet trouble is in stirring single-purpose types into the mixture, for then he may find it difficult to manage a herd of various types of animal. Individually, the beasts may be perfectly good for meat, or milk, or both. The main trouble about indiscriminate crossing, surely, is that it is practised (if that is the correct word) by Grade C farmers who would treat pure-bred animals just as they treat mongrels—and with similar results. Pure breeding and organized crossing are signs of the tidy, the efficient, the ambitious, the aesthetic mind, and not necessarily of genetically superior animals. Indiscriminate crossing is the sign of the gambler, or of sloth, uncertainty, and poverty of spirit, which will not be cured by misdirected charges against the stock resulting from a lack of system in breeding.

Geneticists do not regard heterosis as a special property of cross-breeds or hybrids. It is built in, so to speak, to all matings and breeding systems. From its lowest value in matings within inbred lines, it will reach a peak in matings designed to produce the greatest number of effective gene combinations. Whether these matings will be wide crosses between very dissimilar breeds, or crosses between specially bred lines within a breed, remains to be seen. Meantime, one can regard ordinary pure-bred animals produced by outbreeding as possessing an intermediate and moderate degree of heterosis, by virtue of the fact that they are heterozygous for many pairs of genes. Since inbreeding reduces the number of gene pairs which are heterozygous, the resulting loss of vigour can readily be interpreted as a gradual extinction of heterosis. Indeed, the accumulating evidence of what is called "inbreeding depression" (of vigour) is the main argument for the existence of heterosis in pure-breds and its magnification in cross-breeds.

It is significant that, with all types of livestock, the traits that inbreeding depresses most strikingly are viability and fertility; and that these same traits recover markedly with the re-establishment (by crossing) of heterozygosity. The inference is that they depend on a degree of heterosis for their normal expression in outbred animals, and that they will respond to higher degrees of heterozygosity where these can be obtained by crossing. Evidence from the study of inbred lines of pigs and poultry supports this inference. Accordingly, the practical economic merit of cross-breeding to secure controlled heterosis may well depend more on its beneficial effects on fertility and survival, than on improved growth rate or milk production.

Making Use of Heterosis

The repeated reference to theory in these remarks is not just an attempt to trail a coat in front of hard-headed practical men. Unlike

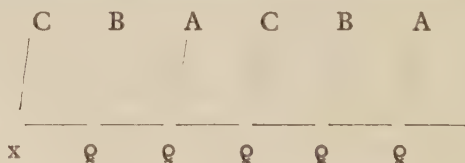
HETEROSIS IN LIVESTOCK

animal husbandry and that component of it which is called practical animal breeding, genetics is a science, and all aspects of it have to be welded together into a comprehensive logical whole. It is conceivable, but improbable, that enough could be found out about heterosis by trial and error to bring about the evolution of methods of exploiting it. Fortunately, it does not seem likely that it will be necessary to rely on waiting and hoping for this to transpire. Much research is being carried out on the nature of heterosis and on methods of making fullest use of it.

One approach is to make inbred lines and pick out those which give good results when crossed—results so good that the vigour lost on inbreeding is not only regained but enhanced. What remains to be seen is whether the enhancement, the superiority of the line crosses over the original pure-breds, is sufficient to pay for the cost of producing and maintaining the inbred lines.

Another is to breed specifically for crossing merit. This is an elaboration of the process by which those breeds which specialize in producing males for crossing—such as Border Leicester, Suffolk and Aberdeen-Angus—ought to be developed: the breed or line is maintained by sires selected because they have produced the best cross-bred offspring.

Yet another is cyclical crossing, either of ordinary outbred stock or of selected inbred lines. The idea behind this is to secure and maintain heterosis in a self-contained system. Males of three or more breeds or lines of the same general productive purpose are used in a regular cycle so that the pedigree of an animal comes to look like :



where the letters A, B and C refer to successive sires from the different breeds or lines. By the time a male of type A is repeated, the genetic residue of the previous one will be small, and so the cross-bred female line is kept in a high degree of heterozygosity.

No colour and type enthusiast will care much for any of these schemes which are being studied for purely utilitarian motives, nor will the producer of store stock who aims at even-looking lots. It may be worth pointing out, however, that the dire results which are alleged to follow breeding from cross-breds are largely imaginary. Users of half-bred ewes do not worry about them, and they can be left to bedevil those who prefer to foster their illusions. There would be *some* extra genetic variation in production characters from the cyclical crossing, but it would hardly be noticed by those accustomed

HETEROSIS IN LIVESTOCK

to the total variation shown by so-called pure-breds. The other two methods—crossing inbred lines, and pure breeding based on merit in crosses—will give less genetic variation but are more troublesome to set up. All three will stand or fall by their economic merits in comparison with pure-breds.

Until the nature and significance of heterosis are better known, it is not possible to foresee whether the object of selective pure-breeding (with or without inbreeding) will be to provide stocks for exploitation in controlled crossing, or whether crossing is a worthwhile short-term expedient to be used as a technique in developing superior pure-breds. One is a means and the other an end, but which is which is anyone's guess for the present. Heterosis is, in either event, inseparably bound up with the potentialities of all systems of breeding.

RECENT DEVELOPMENTS IN PEST AND INFESTATION CONTROL

W. MCAULEY GRACIE

Lately Director of Infestation Control, Ministry of Agriculture

As in so many other fields of work, the past decade has seen many developments in the control of insects and mites associated with harvested food commodities, and of mammalian and bird pests.

One great change has been in the replacement of apathy and indifference by a better appreciation of the heavy toll exacted from production. This alteration of industrial conception of need for pest control smoothed the way for the introduction of control methods, and provided opportunity and encouragement to the scientific worker to acquire and apply knowledge.

In the case of some creatures, there has been no substantial claim that they possess any redeeming qualities which justify their being treated tenderly in the scale of elimination, but in others the question of economic status is one calling for delicate handling. Sweeping changes in industrial practice alter values and call for periodical review of opinions on economic status, with due regard to the desirability of maintaining in appropriate degree the fauna of the country. The good controller of infestation must be a nature-lover and keep a balanced view. It is only on this basis that he can hope to uphold his position in discharging the necessary function of reducing numbers, against the opposition he may expect to encounter from other knowledgeable people or those animated by sentiment only.

Few today would question the need for control of infestation in harvested and processed commodities. Yet this need was by no

means generally appreciated ten years ago. In an article[1] published in 1940, the writer of the present article stated :

“ Attention to the problem was compelled by the disturbing frequency of instances of serious insect infestation of warehouses, granaries, mills and other premises of high capital value, and of rolling stock, lighters, sacks and all other equipment essential to storage, processing and transport. There was heavy loss in value and volume of foodstuffs, with consequent disputes as to liability.

“ There was clearly an absence of universal acceptance of the seriousness of infestation, and, in fact, a definite trade existed in infested commodities, rejected for their original purpose, thereby promoting actively the spread of infestation throughout the country.

“ It was insufficiently realized that major infestation of expensive structures and their valuable contents could result from admission or oversight of some very small quantity of unclean commodity, or some uncleared rubbish in odd corners. Standards of hygiene in buildings and trade varied—and still vary—as between sections of particular industries, whilst in many cases there was nothing remotely resembling any standard. Where standards were low, or absent, evidence was not lacking that there was constant ‘ injection ’ of infested consignments into the channels of trade, thus producing ‘ cross infestation ’ and multiplying the possibilities of major spread of the trouble . . .

“ A preliminary difficulty was the natural reluctance to engage in open discussion of an evil, whose existence in the particular industry it was more convenient to conceal for reasons of trade prestige. Fortunately, that reluctance disappeared as the circle of interested co-operators increased, and it was shown that everybody was ‘ in it ’.

“ The next serious fence was that those industries who took precautions and incurred expenditure on protection were disinclined to do more, and those who had taken no action were disinclined to commence to ‘ clean up ’ so long as there was constant risk of infestation from unrestrained trade and from contaminated imports . . . It became evident that the solution of the problem was outside the power of industry and agriculture, and, in fact, could only be found, if at all, by the Government.”

Public Recognition of the Evil

The case so presented to the Government led to the acceptance by the Department of Scientific and Industrial Research of an appropriate addition to their functions. The Department commissioned the Imperial College of Science and Technology to undertake, mainly at the cost of industry, a survey of the cause, origin and extent of infestation, taking cereals and cereal products as a test case.

That survey was supervised by Professor J. W. Munro, to whom so much is owed for his long pioneer work on infestation of stored products.

In the survey report[2] Professor Munro furnished overwhelming support of the industrial case, and summed up :

“The most important result of the survey is that it demonstrates the occurrence of infestation throughout all the industries producing, housing, transporting, trading in, manufacturing or using cereals and cereal products. None of the industries, nor any section of them, can point an accusing finger at another or hold it responsible for the general evil.

“To those who have had experience of infestation in other industries, who have endeavoured to assess the extent of infestation in them, and have now been privileged to carry out this survey with the co-operation of the grain industry, the outstanding feature of the survey is the fact that infestation is no longer concealed. When the informal committee of the various parties interested in the problem decided to recognize it publicly, it took the most far-reaching—as it was also the most daring—step in combating the evil . . .”

The purpose of giving the foregoing quotations in such length is to emphasize the point so well put by Professor Munro that public recognition of an evil by the parties experiencing it is a major step towards securing control of the evil.

The direct outcome of the survey was the creation of the Pest Infestation Laboratory of the Department of Scientific and Industrial Research. The indirect results, influenced by war conditions, were the provisions of the Infestation Order, 1943 (S.R. & O. 680) and, later, those in Part II of the Prevention of Damage by Pests Act, 1949, a main feature of which is the onus placed on owners or custodians of infested commodities or premises to notify the Ministry of Agriculture of the facts.

Infestation Control in Stored Foodstuffs

Good housekeeping is, of course, a primary safeguard where stocks of foodstuffs are kept. Cleanliness, good ventilation, sound structure, proper stacking away from pillars and walls, and with alleyways for inspection and control action, issuing in strict rotation, segregation of parcels, isolation and examination of stocks of empty sacks, and prompt removal of sweepings and debris, are simple and valuable preventives to the rise of general infestation. It should be remembered that it is often easier to prevent than to cure infestation once it becomes established in a store.

But cases do arise frequently where chemical control becomes necessary. It is then important that the appropriate chemical, whether fumigant or contact insecticide, is selected. The three main factors governing the selection of an insecticide are : (1) that it must not taint the treated commodity or any of its products ; (2) that it should not be injurious to the consumer of the commodity, or involve other risk hazards ; (3) that it should be effective against the particular species of insects present. There are times when the insecticide most effective

against the species present must not be used because of the injurious effect on the "host" commodity.

Recent developments in chemical control methods include the application of DDT and BHC in sprays or dusts. In the form of dusts care is necessary to avoid their coming into contact with the actual commodity to any significant extent. In contact sprays they are usually carried in highly refined oils ; but for treatment of surfaces of structure they are available in water-dispersible powders and emulsions to meet circumstances in which oil is likely to be absorbed. Fogging sprays are in commercial use, but they are mainly effective against flying insects, and their deposits are not normally adequate to provide an effective film.

It is to be noted that these chemicals have a cumulative effect on man, and have lasting properties. The Medical Research Council has, therefore, advised that they should only be used in a way that will ensure that the total quantities of DDT and BHC should not exceed 7 and 2.5 parts per million respectively in the final foodstuff. The important bearing of risk of repetitive treatments with these materials is not to be overlooked.

For empty structures, smoke canisters containing DDT and BHC have an increasing vogue as preventives of infestation. It is necessary to clear the spaces to be treated of food and other debris, or the penetrative quality is much reduced.

In the spray class, pyrethrum remains as a valuable control. A recent development is the admixture of piperonyl butoxide, which effects a saving in pyrethrum without sacrifice of efficiency.

Pyrethrum as a dust for admixture with grain has recently shown its possibilities, but the economic practicability of the method has not yet been determined.

In the field of fumigation, the rapid rise to prominence of methyl bromide is noteworthy. It has great power of penetration, and has been invaluable in controlling infestation in bulk stocks of grain *in situ*. In many cases it has displaced ethylene oxide. Increasing use is being made of carbon tetrachloride-ethylene dichloride mixtures in the proportions of 1 : 3 for the treatment of small quantities of infested commodities, and the results are good.

In an article of this length it is not possible to include precise directions for use, or the appropriate safety precautions for the foregoing chemicals. Full particulars can be furnished by the Infestation Control Division, Hook Rise, Tolworth, Surrey.

Rodent Control

In rodent control there likewise have been considerable developments over the past ten years. In particular, it has been well recognized that it is futile to attempt to control rats and mice in food producing, storage, or processing places unless control is exercised

RECENT DEVELOPMENTS IN PEST AND INFESTATION CONTROL

over the rat population as a whole. Thus it comes about that the fight is carried on against these creatures wherever they may happen to be—in drains, sewers, sewage farms, refuse dumps, transport premises, etc. The local authorities are now charged by the Prevention of Damage by Pests Act, 1949, with continuing to exercise the functions in their districts placed on them by the war-time Infestation Order, 1943, and they are the enforcement authorities, subject to the Minister's requirements.

The methods required to be observed by local authorities and county committees are identical, and through a system of workable area committees contiguous local authorities and County Agricultural Executive Committees are brought into consultation on matters of common interest and co-operation.

Research conducted by the Bureau of Animal Population at Oxford under grant from the Agricultural Research Council demonstrated beyond doubt in the early days of the war that the most effective use of poisons which produced prejudice from sub-lethal doses was after a series of conditioning feeding with the particular kind of food in which the selected poison was to be incorporated for the final treatment. That method created a confidence which ensured that in a high proportion of cases the rats consumed lethal doses.

The method is, of course, expensive in labour, but this is more than offset by the removal of the commodity loss caused by a larger live residue after a direct poison treatment.

The search for a poison not causing noticeable prejudice in the animal, and with negligible risk to most useful animals, has been long and arduous. The present indications are that these conditions are satisfied by the blood anti-coagulant "Warfarin". Baits made with this material are left down for several days and are freely taken. The percentage of toxic principle is so low that single accidental ingestion by other animals does not normally have any serious ill effect. There is real probability that this material will go far in getting rid of infestation, and after the preliminary treatment the amount of labour in keeping down rats may show a considerable saving in manpower costs. It is to be hoped that this opens a new chapter and that there may be other discoveries of like benefit, when such strong poisons as zinc phosphide and arsenious oxide may disappear from the economy, and there may be no difficulties on humane grounds, such as that caused by the use of the slow-acting red squill which, so far, has been necessary in places where useful livestock are present.

Some three or four years ago a special problem arose with large stocks of bagged grain in frame buildings. Mice entered, either in the original bags or on foot, and built up large populations within the piles of grain. There was little external evidence of their presence in such numbers since breeding and feeding took place within the piles, which contained sufficient air in the spaces between the bags, while the requisite moisture was contained in the food consumed.

RECENT DEVELOPMENTS IN PEST AND INFESTATION CONTROL

This serious condition was not amenable to treatment by the normal methods of poisoning and trapping around the piles. A system was devised in which piles of up to 2,000 tons were enveloped in light fabric sheets well anchored to the floor by light chains. The method of joining sheets and the nature of the fabric of the sheets enabled the necessary concentration of gas to be maintained for effective fumigation throughout the piles. The fumigant used was methyl bromide, and the operations were highly successful. The arrangement is applicable to the control of insect infestation, subject to the appropriate higher gas concentration. Several hundreds of thousands of tons of grain have been treated since the introduction of the method. It is interesting to note that this plan has been taken up on the Gold Coast and has become a standard method for treating pyramids of oilseeds etc., against insect infestation.

Other mammalian and bird pests on agricultural lands have not so far furnished much scope for the discovery and introduction of new methods of destruction, where destruction is justified. On the other hand, there has been a considerable development in co-operative effort on a "good neighbour" basis. The Ministry, the County Agricultural Executive Committees, the Forestry Commission, National Farmers' Union, and Country Landowners' Association, have been engaged for some time in stimulating the land interests in the counties to join in measures for area control, using the legal means at present available to them, and not holding back because they cannot get relaxations which, in present circumstances, may not be feasible. The response has been variable, but taking the country as a whole, voluntary co-operation on the lines indicated has proved its value. It has to be recognized that such voluntary co-operation in the interests of owners and occupiers of land themselves offers the main hope of improvement of conditions. A good neighbourly policy will achieve far more than can be obtained through enforcement procedure.

That good neighbour policy is, in the first degree, essential to prevent the spread of certain specially destructive creatures. An outstanding example of this is the grey squirrel which, if unchecked, extends its colonization and builds up new populations at a rapid rate.

Dealing with the Wild Rabbit

The wild rabbit is a major problem. Its seriousness and, unfortunately, the immense toll it takes of production and soil fertility, is insufficiently realized in various parts of the country where the carcass value is a temptation to treat this animal as a source of revenue. It is not easy to change this psychology where it exists, and the work of education has had painfully poor results : but it must go on.

One major development in this particular field is the production of a humane rabbit trap. The Ministry has taken notice of the invention

RECENT DEVELOPMENTS IN PEST AND INFESTATION CONTROL

of Mr. F. E. Sawyer, and in the course of extended developmental research has been impressed with the latest version of this particular invention. In order to popularize the use of humane traps, the new model will replace the gin traps hitherto used in the Ministry's contract service operated by the County Agricultural Executive Committees.

Space does not allow of more than brief reference to results of the lengthy field tests and the modifications made in the trap in the developmental stages.

A first requisite is that a humane trap must be nearly equal in catching efficiency to the gin. The first and second tests of the trap as first produced were made in direct comparison with the gin. The initial test was in June 1951 with 80 "Supersawyers" and 80 gins, set alternately. The new traps were set by Mr. Sawyer, assisted by an experienced gin trapper, while the gins were set by trappers accustomed to their handling. In the seven-day test the humane traps accounted for 565 and the gins 585 rabbits. Up to the third day the Sawyers were slightly in the lead, but some straining of the springs caused the little headway to be lost. The final result indicated that the catching efficiency was satisfactory. A second comparative test appeared to confirm this. That test took place in November 1951 when 90 Sawyers and 90 gins were used in separate block settings. The results of a four-day test were 141 caught in gins, and 135 in Sawyers.

The second requisite was that the mode of catch must show a definite and substantial reduction of suffering. This was well brought out. In the first test the position was that of the 585 rabbits caught by the gins, 579 were taken by the leg, against 24 out of the 565 caught by the Sawyers. At trap inspection 51 live rabbits were in the Sawyers as against 456 in the gins. In the second test the results at trap inspection showed that in the Sawyers 127 of the 135 rabbits were dead, as against 2 out of the 141 in gins.

Two subsequent trials with the Sawyer only were for the purpose of testing mechanical improvements in the trap. Of these the first gave a percentage of 95.8 dead at trap inspection: the second gave 99.0 per cent. The following summary of the Sawyer results in all four tests may be of interest:

<i>Total Number of Rabbits Caught</i>			
Dead on inspection	...	...	869
Alive on inspection	...	...	66
Total	...		935
<i>Way in Which Trapped</i>			
By head, neck or shoulders	...		797*
flank	...	...	95
loin	...	...	11
leg	...	...	32
Total	...		935

*652 caught by the neck.

ANIMAL BREEDING

After brief experience a trapper can set this trap as easily as he can set the gin. The amount of earth work on balance is less with this trap than with the gin.

The base of the trap measures 5 inches by 4 inches. The arms, when set for action, have an outside width of 8 inches, and, when sprung, a height above the soil camouflage of approximately 5 inches. The parts are readily detachable, and being standard are easy to interchange or replace. The trap is compact and easily portable in numbers.

References

1. Pests and the Nation's Food. W. MCAULEY GRACIE. *L.N.E.R. Mag.*, 1940.
2. J. W. MUNRO. *Report of a Survey of Infestation of Grain by Insects.* D.S.I.R., 1940, 47-126.

ABSTRACTS

ANIMAL BREEDING

Observations on the Birthcoats and Skins of Several Breeds and Crosses of British Sheep. A. S. FRASER and M. K. O. Hamada. *Proc. roy. Soc. Edinb., Sec. B.*, 1952, **64**, 462.

Skin and birthcoat samples were taken within a few days of birth, or a little later, from Blackface, Half-bred, Oxford, Welsh, Blackface \times Cheviot, and Suffolk triple-cross lambs. In "coarse" birthcoats, the two main groups of fibres are long and coarse, and short and fine; in "fine" birthcoats, two main groups are distinguished by a very small and a large crimp. In each case, these groups correspond to primary and secondary groups of follicles, and the ratios of the different types of follicles were the same in all the breeds. The differences between coarse and fine, and short and long birthcoats are independent both developmentally and genetically. In the few lambs studied, the coarse type is dominant over the fine type, and the short type over the long type. A theoretical discussion on the evolution of different fleece types is given.

The Lamb's Tail in Relation to Wool Type in British Breeds and Crosses of Sheep. P. BHATTACHARYA and J. HAMMOND. *J. agric. Sci.*, 1952, **42**, 180.

Lambs' tails at about a month old have been collected from two or three flocks of several different British breeds and crosses of sheep, and have been classified into ten grades according to the relative amounts

of wool or hair extending from the base to the tip of the tail. In general, the relative amounts of wool and hair found on the tail of the lamb in the different breeds correspond with the quality of the wool of the adult fleeces of the breeds. Considerable variability in tail grade was found between different individuals in the same flock, so that there is scope for selection in this respect to improve the quality of the wool, especially on the britch. It is suggested that as differences are more obvious on the tail at birth than in the adult fleece, selection for uniformity of fleece might be made at this time.

G.B.Y.

ANIMAL NUTRITION

Sheep

Correct Feeding of the In-lamb Ewe

An article by Thomson [1], full of interest and of much practical value, deals with the feeding of the in-lamb ewe. Experience has shown that a high mortality in ewes and lambs occurs in certain years in arable flocks, particularly when the ground is largely snow-covered from the beginning of the year until lambing time. Work at the Rowett Research Institute has shown that good feeding during the later stages of pregnancy is amply repaid in reduced losses. Some typical results abstracted from the article are given in the table on page 22.

From these results it is clear that undersized lambs are produced by underfeeding during the whole pregnancy, or by underfeeding during the final six weeks although previously well fed, or by a severe check (such as might be occasioned by a snowstorm) during the last six weeks. Good lambs are produced by good feeding throughout pregnancy, provided there is no check, or (with the same proviso) by feeding well during the last six weeks, even though there had been underfeeding in the early stages.

The percentage of weakly lambs and of lamb mortality was highest for average lamb weights of under 8 lb. for the Greyface and Half-bred, under 7 lb. for the Cheviot ewe and under 6 lb. for the Cheviot gimmer. In these cases one lamb tended to be smaller and weaker than its twin; at higher average weights the twins were more even. Underfed ewes not only produced small lambs but also produced less milk. Ewes well fed during the latter half of pregnancy gave twice as much milk over a three-month suckling period as those poorly fed, in spite of an increase of food to the latter during suckling. Also, some poorly fed ewes had no milk available at lambing, when milk is most needed. The poor start of some lambs was not overcome by subsequent equality of feeding and management.

ABSTRACTS: ANIMAL NUTRITION

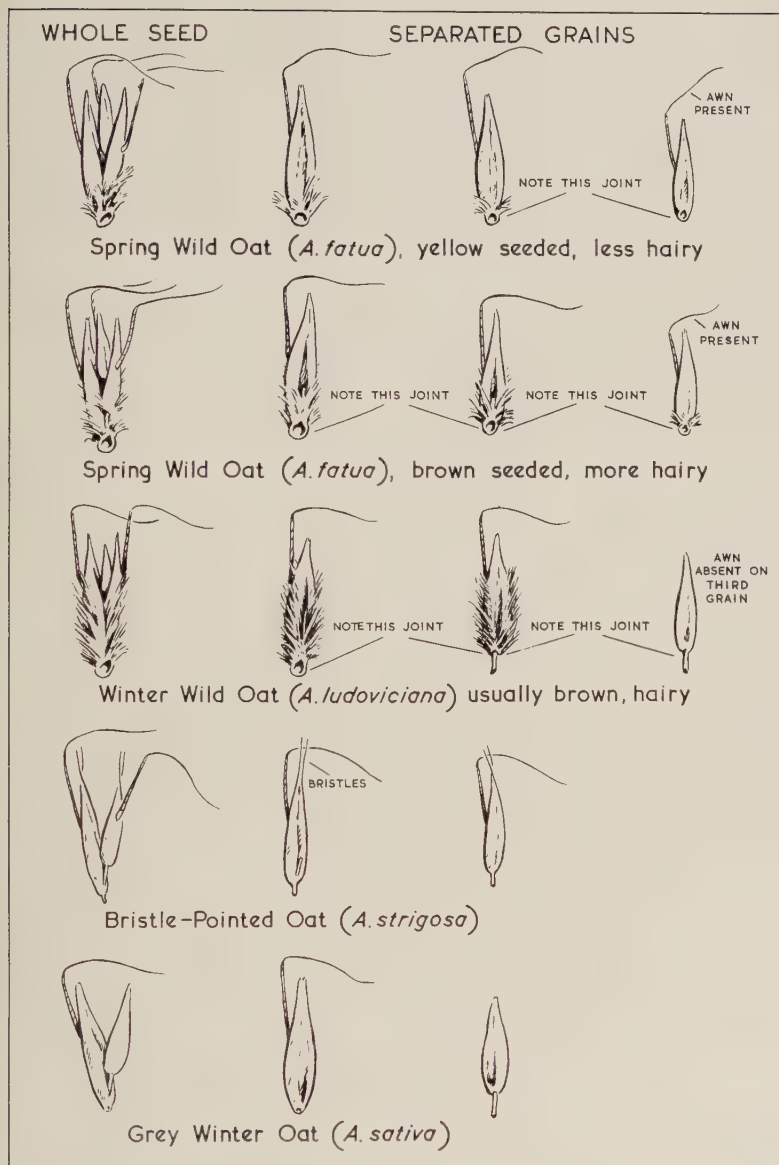
Effects of Various Levels of Feeding on Weight of Ewe and Lamb

<i>Treatment during Pregnancy</i>	<i>Weight Gained or Lost by Ewe during last Six Weeks</i>	<i>Average Birth Weight of each Twin Lamb</i>
GREY-FACED EWES (INDOORS)	<i>lb.</i>	<i>lb.</i>
Poorly fed throughout	- 4.4	7.5
Fed to fatness, then checked during last six weeks	- 5.4	7.3
Poorly fed up to last six weeks, then fed to appetite	+ 24.6	10.3
Fed to fatness throughout	+ 16.2	10.1
Fed to fatness, but starved for two periods of 48 hours each during last six weeks	+ 3.1	9.0
CHEVIOT GIMMERS (INDOORS)		
Poorly fed from mid-term	- 2.5	5.0
Well fed from mid-term	+ 15.0	7.7
CHEVIOT EWES (OUTDOORS)		
Grazing only for whole season ..	+ 4.3	7.5
Grazing plus trough feeding ..	+ 5.4	8.5
HALF-BRED EWES (OUTDOORS)		
Fed to fatness, then food reduced during last six weeks	+ 1.0	9.5
Increased in weight gradually throughout	+ 6.0	10.5
Fed to fatness, checked during 13th to 16th weeks, then fully fed ..	+ 8.1	11.1
Fed to fatness throughout	+ 21.6	11.9

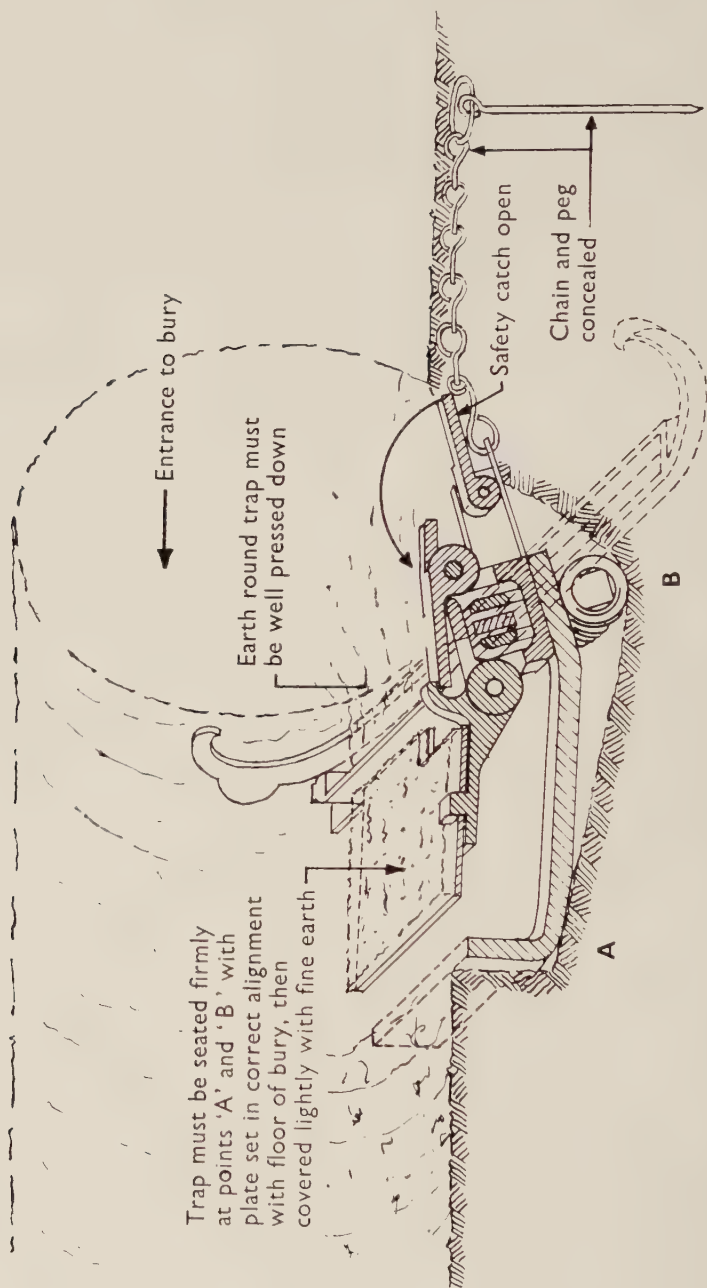
Pregnancy Toxaemia (twin-lamb disease), which develops in some ewes about three weeks before lambing, could be prevented if the ewes were in a rising condition for the last six weeks, no matter what their previous treatment. Ewes losing weight were prone to this disease, as were those either fat or lean which suffered a check during this last period.

For ewes of heavier breeds getting a little food from grass, Thomson recommends four alternative supplementary rations on the following lines :

	<i>lb.</i>
1. Turnips or swedes	10
Hay	$\frac{1}{2}$ -1
Oats plus linseed-cake meal (equal parts)	1
2. Good quality grass silage	5
Oats	$1\frac{1}{2}$
3. Oats and cubed dried grass (equal parts)	2-2 $\frac{1}{2}$
4. Oats and bran (1 part each) and linseed-cake meal ($\frac{1}{2}$ part.)	2-2 $\frac{1}{2}$



Some of the more important characteristics in the identification of the seeds of wild and cultivated oats.



Method of placing "Sawyer" trap in the hole

THE "SAWYER" TRAP



At rest



Set, but with safety catches
" on "



Set for action, with safety
catches " off "

THE MARGINAL LANDS AND HILL PASTURES OF THE
NORTHERN PROVINCE (See pp. 42-6)



Drainage on molinia moors in the Border Country : an indispensable preliminary to any improvement scheme.



The results of a typical improvement scheme on marginal land in East Cumberland. The reseeded pasture on the right contrasts vividly with the *nardus fescue* type of herbage with which the area was originally covered.

ABSTRACTS : ANIMAL NUTRITION

In each of these rations the protein content of the dry matter is about 13 per cent.

Thomson concludes by stating that supplementary feeding should be kept to a minimum in early pregnancy. If at that time pastures are bare or snow-covered, no more than 1 lb. of hay or its equivalent should be supplied. Pure salt and mixed mineral licks should both be put out on posts, and adequate provision should be made for watering.

Effects of Food Protein on Milk, Lambs and Wool

A paper by Canadian workers [2] describes the effect of the protein content of the ration upon the quantity and composition of ewes' milk. They quote a great deal of other work which finds high correlations between feeding in the later stages of pregnancy and milk production, between percentage of food protein and percentage of milk protein, and between milk production and lamb weights at weaning. In their own experiments, the energy content of the various rations was the same, but Ration 1 contained 7.3 per cent total protein throughout pregnancy and lactation, Ration 2 had 7.3 per cent until six weeks before lambing and 10.5 per cent thereafter, and Ration 3 had 10.5 per cent throughout pregnancy and lactation. Single lambs were suckled. The results showed no important difference between the effects of Rations 2 and 3, but both were definitely superior to 1; the lambs from Treatments 2 and 3 were 1 lb. heavier at birth and 10 lb. heavier at weaning than those from Treatment 1; in addition, 50 per cent more milk, which was richer in both fat and protein, was produced on Rations 2 and 3 as compared with Ration 1.

A further paper [3] by the same authors deals with wool as well as lamb production. In experiments, Ration 2 (7.7 per cent protein, raised to 10.5 per cent six weeks before lambing) was as efficient as Ration 3 (10.5 per cent protein throughout pregnancy and lactation) for lamb production, but the latter, which provided 0.25 lb. of digestible crude protein per head per day, gave a significantly greater yield of wool. Both 2 and 3 were superior to 1 (7.7 per cent protein throughout) in all respects.

Coop [4] has also concluded that wool production is greatly influenced by the type of feeding before parturition and less so by the feeding during lactation. A high plane before lambing produced 0.09 lb. more unwashed wool per week than did a low plane, but the difference was reduced to 0.03 lb. during lactation. The level of nutrition after lambing was most important in deciding the weaning weight of the lambs, and, on a low level, more lambs were lost.

Feeding Value of Grass

The value of improved hill pastures for the fattening of lambs is reported [5] from a six-year trial in Wales. Pedigree grasses produced

840 lb. lamb per acre compared with 747 lb. from commercial grasses, and only 298 lb. from unimproved pasture. The mixture sown on the improved grazings was (in lb. per acre) perennial ryegrass 12, Italian ryegrass 10, cocksfoot 6, timothy 6, crested dogstail $\frac{1}{2}$, wild white clover 1 ; although the pedigree strains cost 44 shillings per acre more than the commercial, the value of the lambs was £6 more in the case of the pedigree grasses.

Timothy foggage has been compared with grass silage for the wintering of Suffolk \times Half-bred hogs [6]. The foggage was laid up in September, given 4 cwt. "Nitro-Chalk" per acre, and grazed for five hours each day for fourteen weeks from January to April. Weight gain averaged $14\frac{1}{2}$ lb. Another group of hogs fed on grass silage (13.8 per cent crude protein in the dry matter, and pH 4.8) gained only 4.2 lb. per head over the same period. The average daily dry matter intake was 1.8 lb. for the foggage and 1 lb. for the silage group, and worm egg counts were over three times as high in the silage group. It was thought that the higher infestation was due to the fact that the silage hogs, disliking the silage, grazed their holding paddock more thoroughly than did the others. (It should be pointed out that although the foggage was only slightly higher in protein than the silage—14.2 per cent on the average, compared with 13.8 per cent—the indifferent fermentation quality of the silage as shown by the high pH may have been a factor affecting palatability and consequent intake.)

Worm Burden and Growth

The relation between worm burden and liveweight increase of sheep is discussed in two recent papers [7 and 8]. In the first, experiments on Half-bred \times Suffolk shearlings showed that when the sheep were kept on clean pasture, which was protected from infection by bagging the animals, they put on an average of 39 lb. in 122 days, as compared with 33 lb. by sheep on comparable pasture constantly reinfected by the droppings. A similar experiment on lambs did not produce any clear cut results, possibly because of the influence of birth factors.

The second paper describes an experiment lasting two years for Blackface ewes and eighteen months for their lambs. One group of ewes was given a daily supplement consisting of a mixture of 1 part oats and 2 parts linseed-cake meal at the rate of 1 lb. per ewe. The lambs born of these ewes shared their dams' supplement until weaning, when they were given their own supply—gradually increased to 1 lb. daily per lamb. The other group and their lambs received no supplement. No significant differences in weight, worm burden or faecal egg counts were observed between the ewe groups, but wool yield was increased in the supplemented group. The supplemented lambs, however, had significantly higher body and wool weights, reduced egg counts, and smaller seasonal increases in worm-egg production. The cost of the supplement was twice that of the extra wool and mutton it produced, but a weekly

supplement given only in winter might be both practical and economic. In all cases the infestation was low by the usual standards, and under worse conditions an even greater difference in response might have been obtained.

Grazing Heather

The seasonal value of heather and hill grass respectively was demonstrated [9] by putting Swaledale ewes and their lambs on heather and an equal number on grass. Up to the beginning of June the "heather" lambs made greater gains, but by the beginning of July the "grass" lambs had drawn level with them; thereafter there was no significant difference between the two. Since lamb growth in the first month or so is a reflection of the ewe's milk supply, it would seem that heather has a contribution to make before growth of grass on the hills becomes effective in the late spring or early summer.

Arrangement of Feeding Experiments

In conclusion, reference may be made to two papers dealing with methods of experimentation in sheep feeding. The first [10] describes the tethering of sheep on heather moorland so that the plants and the portions of the plants eaten could be accurately observed. Two sheep were tethered, one each to stakes set 27 feet apart, by 15 foot tethers, and a water trough was provided at the intersection of the circles. Changes of site were made as required, which would be approximately at five-day intervals on this length of tether. Close observations were made of the type of material eaten, and comparable samples were taken from nearby areas protected by cages from grazing by intruding sheep. Analysis of the samples and of the faeces passed by the experimental sheep permitted the determination of digestibilities by the lignin-ratio method.

In the second paper [11] the feeding of sheep eight times a day at approximately hourly intervals between 9.30 a.m. and 5.15 p.m. was compared with one large feed at 9.15 a.m. In both cases the total feed was 1 lb. of chopped hay and 1½ lb. of a concentrate mixture; all the sheep were allowed free access to water and mineral licks. After nine weeks the treatment of the two lots of hogs was reversed and the experiment was continued for a further nine weeks. Two interesting findings were made: (a) there was a very much greater increase in body weight in the animals fed frequently; and (b) the greater gain was accomplished on considerably less food (the frequently fed sheep left more food uneaten). The importance of this is twofold. When laboratory studies are being made of the digestibility of, say, herbage, the sheep should be fed the cut material a little at a time (thus simulating natural grazing) and not merely in two daily feeds. Livestock which are normally housed (e.g., cattle in winter) could perhaps be fed more economically by some method of automatic, frequent feeding. The authors suggest that their results warrant further study of the problem, with perhaps an extension to single-stomached animals.

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S.M.B.

MACHINERY

Green Crop Water Requirements for Optimum Growth. *N.I.A.E. Report*, 1952, C.S. 16.

This report discusses the amount of water that crops need for "optimum" growth, in relation to the amount they receive in the form of rain. The growing period is assumed to extend from April to September, and it is reckoned that during this period soil drainage is negligible. Reference is made to the concept of "potential transpiration" put forward by Penman in an earlier paper (H. L. Penman. *Quart. J. R. Met. Soc. London*, 1950, **76**, 372) and it is argued that the average irrigation need for any place can be reliably calculated from a knowledge of the rainfall and the potential transpiration.

Maps are included showing the average rainfall (annual, and April to September), average potential transpiration, and expectation of irrigation need in various areas of Britain, and it is concluded that all of England east of the line Grimsby to Bournemouth, needs irrigation for "optimum" growth of crops at least two years in three, while parts of Suffolk, Essex, Kent and Sussex need it nine years out of ten. The average need is

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reckoned to be 2 inches of rain over the whole of the eastern area referred to, and 5 inches in the Thames Estuary. The deficiency rises to 10 inches in the Thames Estuary in a year of summer drought.

Simple Soil Test tells When to Irrigate. C. H. DIEBOLD. *Through the Leaves*, Great Western Sugar Co., Denver, Colorado, 1953, **41**, 29.

After the N.I.A.E. study referred to above, it is interesting to read how sugar beet growers in Colorado—where the growing of such crops is entirely dependent on irrigation—are advised to decide when water is needed. The method recommended by the U.S. Soil Conservation Service is simply as follows :

First take a handful of soil (using a spade to get it) from a depth of 6-12 inches. Second, squeeze the soil firmly in the hand three or four times, "using about as much pressure as is needed for a 'hard'-milking cow". If the soil is too dry to form a ball when so squeezed, then it contains less than one-quarter as much readily available moisture as it can hold (at field capacity). In this case, water ought to have been applied sooner. If the soil does form a ball, the next test is to throw it up about 1 foot and catch it in the open palm of the hand. Do this five times. If it breaks up in the process, then the soil contains between one-quarter and one-half of the amount of readily available moisture that it can hold. It is at this stage that the soil should be irrigated. If the soil ball remains durable after the tossing and catching, then the amount of moisture held must be at least three-quarters of the amount that can be retained, and irrigation is not yet needed.

This same test can be applied to almost all soils, including sandy loams and loamy sands, but not to sands. The amount of readily available water that can be held by the various types of soils in the Colorado area—based on a large number of irrigation trials—ranges from 0.7 inches per foot depth for coarse sands, to 2.1 inches per foot for medium to fine textured soils.

The G.W. System. *Through the Leaves*, Great Western Sugar Co., Denver, Colorado, 1953, **41**, 4.

While research on the use of "down the row" thinners continues steadily in Britain, this American publication shows that the practice is becoming widely accepted in the important beet-growing area in Colorado. A total of 713 thinners are now being used in the area, and more than 11,000 acres were completely machine-thinned in 1952. In this issue the "Windsor" system of complete mechanical thinning is described and illustrated in detail, beginning with the method of assessing plant population and of calculating just what treatment the crop should be given.

For the first operation the thinning head carries eight blades which make a cut $1\frac{3}{4}$ inches wide every $3\frac{1}{2}$ inches along the row. This operation is applied to all but very thin stands (all above an average 24 beet-containing inches out of every 100 inches). In the next operation,

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carried out after 3-7 days, 16 knives are used on each head, and the size of knife chosen ranges from $\frac{5}{8}$ inch to $1\frac{1}{4}$ inches according to the original stand. This second operation is carried out in the opposite direction to the first, and this, combined with the usual machine hoeings, is claimed to result in very clean crops with practically no hand labour. It is stated that most of those who tried complete mechanical thinning in 1952 will do it again, results in terms of yields being satisfactory and the saving of labour appreciable.

The continued optimism of responsible American workers concerning the use of down-the-row thinners should at least encourage further research on the method in Britain.

Pelleted Seed Trials. *N.I.A.E. Technical Memorandum No. 91/53.*

Seeds coated with bonded powders so that each seed is built up to a uniform spherical shape are available commercially in France and in the U.S.A. They are pelleted by a process similar to that used by manufacturing pharmacists for coating pills with sugar. This memorandum describes some experiments made to assess the value of these pelleted seeds for various crops in Britain.

In one experiment, rubbed sugar beet seed (variety Klein E) was sown at seed rates equivalent to $1\frac{1}{2}$ -inch and 3-inch spacing. One half of the seeds were planted untreated, the other half were planted as pellets. A modified N.I.A.E. single-seeder drill was used to sow both the treated and untreated seed, and it was found that rubbed seed could be drilled as regularly as pelleted seed.

The results of the experiment show that there was some saving in the singling time where pelleted seed had been sown. This saving was not great enough to make the cost of the pelleted seed worth while. It was suggested, however, that pelleting might allow fungicides and insecticides to be incorporated in the coating material and that these agents might be particularly effective when applied in this way. If so, the advantage might make the cost of pelleting worth while.

An experiment was also made with onions. It was found that, for a satisfactory crop, a seed rate of seven seeds per foot would be required. There was some saving on the amount of seed sown, but the saving was more than offset by the cost of pelleting the seed.

In trials on lettuce there was a saving of eight man-hours per acre in the singling time. This would not pay for the pelleting of the seed, but it was considered that the less dense stand of seedlings which the pelleted seed produced could have been left unsingled for a longer time without losses in the final crop, and that this might have a value to be set against the cost of pelleting.

Measurements of Grain Pressures on Bin Walls. ROBERT A. SAUL. *Agric. Engng*, 1953, **34**, 231.

Exact data for use in designing silos for grain has not been available in the past because of the difficulty of measuring or calculating the

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complex pressures exerted by the grain. This paper describes a continuing experiment on the use of strain gauges to measure the loads in a specially-constructed, rectangular wooden bin with a floor area of 11 feet \times 11 feet. Pressure panels were let into the floor and into one of the sides. Extended trials have established that the gauges are reliable. The measurements made so far have confirmed also the accuracy of some of the assumptions made in the past, and it is interesting to note how closely the results agree with pressures calculated from the Janssen formula employed by silo manufacturers. They have also provided some new information which could not otherwise have been deduced.

Readings on the floor panels showed that the floor load is low near the walls, and the explanation for this is that the vertical load is partly supported by the walls. Lateral wall pressures were small just above the floor, and this is due to the floor friction holding back part of the sideways thrust.

Opportunity was taken to examine pressures after the silo had been filled in three different ways. In the first method a spout was fixed above the centre of the bin and the grain was allowed to pile up until it was high enough to level off to the required depth. When the silo had been filled thus, the floor pressures were high in the centre. Next a cone-shaped deflector was fixed under the spout, and when the silo had been filled in this way the floor pressure was low in the centre. In the third method the silo was filled in several stages: a moving spout was used, and each two feet the flow was stopped and the grain was levelled off before the next layer was put in. This method of filling gave a fairly uniform pressure over the floor area except for a falling off in pressure near the walls. Measurements were continued for several days after the silo had been filled. In all the experiments the grain used was maize.

The use of an air flow meter in different parts of ventilated silos in Britain has shown that air flow can vary considerably with the method of filling, and these American experiments on filling methods lend support to the conclusion that even filling is an important factor in securing uniform ventilation.

H.J.H.
C.C.

FRUIT

Plant Hormones in Relation to Fruit Set and Development

As fruit thinning by hand is laborious, much attention is being given to the reduction of fruit set by spraying with chemicals, including α -naphthalene acetic acid (NAA). Luckwill, in two recent papers, describes work on the fundamental causes and mechanism of fruit drop, and the effect of NAA on fruit set and development.

Three well-defined stages are recognized in the development of apple seed [1] :

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STAGE 1. The central nucleus of the embryo-sac, after fertilization by one of the male gametes, divides rapidly to form a large number of free endosperm nuclei, but the cytoplasm does not become divided up by cell walls. The fertilized egg-cell divides to form a small pro-embryo, attached by a suspensor to the wall of the embryo-sac. This stage generally lasts three to four weeks.

STAGE 2. The endosperm becomes divided up by cell walls and fills the embryo-sac. Simultaneously the embryo begins to make rapid growth and soon digests the primary endosperm. A secondary endosperm is developed and renewed from the outer layers as it becomes digested on the inner layers. The maximum volume of endosperm is reached when the development of the embryo is complete.

STAGE 3. There is no further growth of the embryo or endosperm, and the seed matures.

Hormone production was judged by the ability of extracts to induce parthenocarp in tomato; in both Lane's Prince Albert and Crawley Beauty the first peak of production occurred at the beginning of Stage 2, when cell walls were forming in the endosperm about three to four weeks after petal-fall. A second peak, coinciding with the end of June-drop, occurred at the end of Stage 2. These results agree with those for Beauty of Bath reported in 1948, and strengthen the suggestion that the endosperm produces a hormone concerned in the control of fruit drop. Unusual features observed in the experiments concerning Lane's Prince Albert were the large number of seeds that aborted, following the arrested growth of the embryo, and the larger size of the fruits containing many aborted seeds.

In all three varieties fruit drop was low during periods of very active hormone production, abscission probably depending on the strength of the hormone stimulus coming from the seeds. Extracts from very young apple seeds, however, did not induce parthenocarp in tomato, and it is postulated that the initial hormone stimulus is different from the later ones, or that it originates in some tissue outside the seed.

EFFECT OF NAA APPLICATIONS. When NAA is applied to apple trees at any time between full bloom and two to four weeks after petal-fall, there is a reduction in the number of apples that mature. There appear, however, to be two quite distinct mechanisms involved [2]. At full bloom NAA appeared to prevent fertilization by interfering with pollen-tube growth, inducing a typical incompatibility reaction between the stylar tissue and the pollen tubes. There seemed to be no increase in the physiological drop of developing fruitlets. When applied after blossom, NAA increased the drop of young fruitlets, and it is suggested that this drop was the direct result of seed abortion induced by the applied growth substance. The exact period during which a growth substance can cause abortion was not determined in these experiments, but it obviously varied from variety to variety; in Crawley Beauty it seemed that NAA had no influence on seed development once the

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endosperm had passed from the free nuclear condition to the cellular state (beginning of Stage 2). In addition to inducing seed abortion, the applied NAA temporarily inhibited abscission for a period of a few weeks.

Early thinning of fruit is usually accompanied by an increase in fruit size, but when the thinning was done by NAA this was not always the case. There is evidence to show that the reduction in leaf area that followed spraying with NAA was not the major factor involved, and it is concluded that NAA has a direct inhibiting effect on fruit growth, which is more pronounced the later the spray is applied. To avoid these adverse effects it is suggested that the concentrations of NAA should be low (e.g., 15 p.p.m.), and that they should be applied within ten days of petal-fall.

Branches of Miller's Seedling, thinned with NAA, failed to blossom the following year, suggesting that the treatment is probably not effective in controlling biennial bearing in this variety.

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H.B.S.M.

GLASSHOUSE CROPS

Watering Tomatoes under Glass. J. P. HUDSON and P. J. SALTER. *Misc. Publication No. 1*, University of Nottingham School of Agriculture, Dept. of Horticulture.

This is a preliminary account of the effects of different water regimes on the growth and yield of tomatoes. Over a period of five months, tomatoes growing in glasshouse border soil were subjected to four different water regimes, in which the soil moisture was allowed to fluctuate only between field capacity and a pre-determined level of dryness. Soil moisture measurements were made both by the porous-pot form of tensiometer, and by the plaster of Paris electrical resistance block. The tensions at which water was applied were 7, 15, 30 and 60 cm. of mercury as recorded by the tensiometer gauges; whenever a plot was watered, sufficient was applied to re-wet the whole bed of soil to approximately field capacity. There were wide variations in the volume of water applied and in the frequency of application for the various treatments, ranging from 3 to 70 gallons per plot, and from daily watering to monthly applications. Two varieties were grown—Ailsa Craig and Single Cross. The total yields (including green fruit) of Ailsa Craig varied from 9.2 lb. per plant in the wet plots to 6.6 lb. in the dry plots; Single Cross varied

from 7.2 lb. per plant in the wet plots to 4.6 lb. in the dry plots. These experiments indicate (*inter alia*) that the heaviest yields of tomatoes are produced under the water regime that maintains the plant in the most active vegetative growth.

Some Cultural Developments in Glasshouse Crops at Fernhurst.
G. D. LOCKIE. *Fernhurst Bulletin* No. 1, 1953.

A description of some of the recent developments in the glasshouse section of the Fernhurst Research Station (Plant Protection, Ltd.), including details of the construction and orientation of the glasshouses, methods of cultivation of tomatoes (the chief crop) in border soil and in raised beds, and the watering and nutrition of the crop, are given in this report.

The importance of careful attention to watering is emphasized, the aim at Fernhurst being to start the tomato crop with all of the soil, except the top 6-8 inches, at field capacity. This is regarded as sufficient on this soil for the crop's needs for about six weeks from planting. During the past two seasons, the practical use of gypsum blocks and soil tensiometers for measuring soil moisture has been investigated. Experience has shown that the porous pot of the tensiometer must be in position before the roots have grown into the surrounding soil. Where tensiometers were used in raised beds watered by the drip-feed system, the gauge readings were very variable and it was not found possible to select a position which would give a satisfactory watering time for the whole of the bed.

Experiments in the growing of tomatoes in raised beds, and their manuring, have extended over several seasons. To date, only the drip-feed system of watering has been compared with the conventional hose-pipe system, but the constant-level method is being tested this year. Modifications of the usual drip-feed method are also described.

E.S.

NUTRITION OF HORTICULTURAL CROPS

Treatment of a Lime-Induced Manganese Deficiency on Peach Trees. W. B. HEALY. *N.Z. J. Sci. Tech.*, 1953, **34**, 386-96.

Peach trees growing in New Zealand on a fertile loam (pH 7.5) showed symptoms of manganese deficiency; in dry years, the symptoms were more pronounced. By laboratory methods the manganese content of the soils was estimated as satisfactory. The investigations described were designed to examine and correct the soil condition which was making the manganese unavailable to the peach trees. Treatments included application of manganese sulphate in sprays, by placement round the roots, or by solid injections into the tree trunks, and the acidification of the soil by applications of sulphur. After these treatments had taken effect, they were followed by leaf and soil analyses.

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Manganese sulphate sprays were effective in preventing deficiency symptoms—the manganese content in the leaves rose from 12 p.p.m. to 200 p.p.m. In the year following spraying, however, the symptoms reappeared and the manganese leaf content fell to the original level.

Manganese sulphate, sulphur, or manganese sulphate plus sulphur added to the top 6 inches of soil, in a circle of 6-foot radius around the tree, failed to correct the deficiency. It appeared that the soil condition quickly made the added manganese unavailable, since the increase in the manganese leaf content was not appreciable.

Where solutions of manganese sulphate were applied in trenches around the roots, a temporary response was noticed in the foliage, but the effect was only transient.

The addition of $1\frac{1}{2}$ tons of sulphur per acre caused a fall in soil pH from 7.2 to 6.1. This reduction in soil pH, however, did not result in a significant increase of available manganese for the peach tree roots. It was also shown that the effect of rising ground water (pH 8.0) in wet periods cancelled out any beneficial effects this sulphur treatment might have caused over a period of time.

Solid injections of manganese sulphate into the tree branches increased the manganese content of the leaves and corrected the deficiency.

It is concluded that the most practical corrective treatment involves the use of manganese in the lime sulphur sprays shortly after the petal-fall stage.

Lime-Induced Manganese Deficiency on Glasshouse Roses.
D. M. MASSEY and O. OWEN. *Ann. Rep. exp. Res. Sta. Cheshunt*, 1951, 81-3.

Manganese deficiency was reported in five varieties of roses: Roselandia, Lady Sylvia, Talisman, Autumn and Richmond, and was corrected by incorporating sulphur at the rate of 4 oz. per sq. yd. into the top 4 inches of soil. After treatment the pH of the soil fell from 7.3 to 6.4, the sulphur being applied when the trees were dormant. By the following autumn the level of manganese in the leaves had risen to 106 p.p.m., compared with 23 p.p.m. in the untreated soil.

Whilst the symptoms of the deficiency (leaf mottling) were eliminated, the treated trees showed a retardation in development during the first few weeks of the growing season; the variety Richmond was particularly affected. By mid-season, however, growth was normal.

W.P.

CROPS AND PLANT BREEDING

Cercospora Leaf Spot of Sugar Beet

Before the war, *Cercospora beticola* was not regarded as a serious trouble in European beet-growing areas except in Mediterranean regions (Italy, Spain, Balkans), and in the southern U.S.S.R. Since the war, however, it has increased considerably in central and western Europe. It is discussed in articles by Margara [1], Schlösser [2] and Bronner [3]. Schlösser suggests that this change in status of the disease may be due to new physiological races brought in with American seed imported as a relief measure after the war; he also attaches importance to the extensive use after the war of fresh seed—a fruitful source of inoculum.

Cercospora causes loss of leaves, which leads to a drop in yield and, because of a tendency of the tops to regrow, an increase in noxious nitrogen in the roots. Schlösser estimated experimentally that the loss in sugar per hectare under German conditions was about 10 per cent from a late infection (July 15) and 30 per cent from an early infection (June 1). The losses in leaves were from 20 per cent to 60 per cent, and the increase in noxious nitrogen from 7 per cent to 22 per cent for the early and late infections. In the Paris region, Margara found that there was a loss of 40 per cent in the sugar yield from attacks which were not exceptionally severe.

Methods of control are the use of stored seed, spraying with copper preparations, and growing resistant varieties. Margara has tested a range of varieties in induced epidemics, and classified them into four groups: fairly resistant, not very susceptible, susceptible and very susceptible. The susceptible group includes nearly all European varieties. Kleinwanzleben RC and certain American varieties are fairly resistant. When the disease is present they yield more than the susceptible varieties, but in the absence of the disease they are unsatisfactory beets—deficient in yield, prone to bolting and with poor root conformation. Bronner attributes their faulty root shape to the use of *Beta maritima* in their parentage.

As regards the possible production of better resistant varieties, Margara points out that little is known of the nature or inheritance of resistance to *Cercospora*. He observed that crosses between resistant and susceptible lines were susceptible. He suggests that, to obtain resistant varieties which are satisfactory in the absence of the disease, it may be necessary to use selected inbred lines and imitate the hybrid corn method—as American beet breeders have sought to do. This may involve the use of male-sterile lines as seed parents.

Cold Resistance in Winter Wheats

Diehl [4] summarizes a considerable amount of work on this important problem. He studied a range of eight varieties, the cold resistance of which

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was known from their behaviour in the field and in freezing tests. Physiological characters which gave a reasonable, though not exact, agreement with degree of resistance, were osmotic pressure (measured cryoscopically) and rate of growth in length of the second leaf during the winter. The more resistant varieties had higher osmotic pressure and slower growth. Morphological characters associated with resistance to cold were small cell size and fewer secondary roots per tiller. This latter character—when observed on varieties in a comparable stage of growth, after hardening but without frost damage—ran almost exactly parallel with resistance.

Oat Variety Trials

Trials with winter oat varieties are reported by Kelly [5]. The varieties Grey Winter (control), Picton, 10/3, S.147 and S.172, were tested in three-year trials run by the National Institute of Agricultural Botany at their headquarters trial ground and at various sub-stations. At Seale-Hayne (Devon) Marvellous was substituted for 10/3, at Wye (Kent) 10/3 was omitted, and in a single trial at a Cambridge centre S.172 was omitted. There were in all fifteen trials in which all five main varieties were included. Their average yields of dry grain in cwt. per acre were : Grey Winter, 19.70 ; Picton, 22.14 ; S.172, 22.23 ; S.147, 22.56 ; and 10/3, 23.36. In the trials in which 10/3 was not included, S.147 improved its yield relative to Grey Winter. Some lodging of Grey Winter occurred in all the twenty-four trials which came to harvest, while S.172 never lodged ; of the other three main varieties, S.147 resisted lodging the most and 10/3 the least. Grey Winter was least affected by frost, the other main varieties showing little difference from each other. Picton and Grey Winter were resistant to stem eelworm and usually had about 2 per cent less husk in the grain than the other main varieties. Marvellous had a very high husk content and was badly affected by frost.

At an East Yorkshire centre the performance of spring-sown Star was compared with the winter oats ; in three years' trials the new winter varieties gave greater yields.

In the same journal, Kelly [6] reports the results of trials with spring oat varieties under upland conditions. In one series—with centres in Derbyshire, Staffordshire, Brecon and Somerset—the Svalöf varieties Orion III and Primus were compared with the U.S. varieties Clinton and Richland Iowa, and with Canadian 601. In the second series—with centres in Montgomeryshire, Radnorshire and Somerset—the land races Radnor Sprig and Black Tartar, and the Welsh P.B.S. varieties Maldwyn and S.220 (both from Victory \times Radnor Sprig), were compared with Victory. Several trials could not be harvested satisfactorily and no very definite recommendations can be made. Of the early-ripening varieties (first series) Orion III, Primus and Clinton seem worthy of further trial ; in the later-ripening varieties (second series) the performances of Radnor Sprig and Black Tartar were disappointing.

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J.L.F.

DAIRY BACTERIOLOGY

The Role of Micro-organisms in Dye-Reduction and Keeping Quality Tests. II. The Effect of Micro-organisms when added to Milk in Pure and Mixed Culture. ELLEN I. GARVIE and A. ROWLANDS. *J. Dairy Res.*, 1952, 19, 263.

It was shown in Part I (abstracted in this JOURNAL, 1953, No. 19, 311) that during the incubation of milk at 22 or 37° C. enrichment of different types of organisms occurs. The investigation was extended to the use of pure cultures, either alone or mixed. Marked differences were found in their ability to cause milk spoilage—measured by the alcohol precipitation and the clot-on-boiling tests. Staphylococci, some micrococci, strains of *coli-aerogenes* and some group B strains of streptococci, actively reduced methylene blue at 37.5° C. Achromobacteria, chromobacteria, microbacteria, streptococci of groups B and E and two heterofermentative streptococci, all common milk organisms, were inactive. *Str. cremoris* types failed to reduce the dye at 37.5° C. The mixing of pure cultures had no visible effect on dye reduction at 37.5 and 22° C., but at 37.5° C. the *coli-aerogenes* cultures, staphylococci and a micrococcus grew faster than *Str. lactis*. *Str. lactis*, however, grew more rapidly at 22° C. than any of the other organisms.

The organisms mainly responsible for dye reduction are those which are favoured at 37.5° C., although at 22° C. these are not necessarily responsible for milk spoilage.

Studies in the Bacteriology of Milk. IV. The Gram-negative Rods of Milk. Y. ABD-EL-MALEK and T. GIBSON. *J. Dairy Res.*, 1952, 19, 294.

Alkaligenes viscosus was often found in raw milk but it failed to produce a ropy condition in milk or other media. A new species, *A. tolerans*, was found in laboratory-pasteurized milk and is described by the authors. It differs from *A. viscosus* in its heat resistance, inability to attack fats and its poor growth in artificial media.

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An Improved Medium for Lactobacilli. MARY BRIGGS. *J. Dairy Res.*, 1953, **20**, 36.

The lactobacilli are notorious for their fastidious nutritive requirements.

The author has evolved a medium which gives good growth of all species of lactobacilli even when freshly isolated. This will simplify future work on the classification of these organisms.

The So-called Nascent Bacteriophage Phenomenon. A. R. WHITEHEAD and LOLA MCINTOSH. *J. Dairy Res.*, 1953, **20**, 60.

Some strains of streptococci appeared to be lysed by a newly-formed (nascent) bacteriophage which did not normally attack them. The apparent lysis was shown, in reality, to be an inhibition produced by high concentrations of the phage, and it is, therefore, unnecessary to assume special potency for the nascent form.

This inhibitory effect was found to be common among strains of *Streptococcus cremoris* and *Str. lactis* and was exhibited only when high concentrations of the phage were used for lytic tests.

Note on the Corrosion of Aluminium Dairy Equipment by Water. G. H. BOTHAM and W. R. BRYSON. *J. Dairy Res.*, 1953, **20**, 154.

It was found that aluminium became rapidly pitted when immersed in water containing copper derived from copper water-pipes. The pitting made sterilization difficult and affected the hygienic quality of the milk. The copper could be removed by passing the water over a synthetic resin (Zeocarb 215).

Field Experience with Antibac, a New Type of Chlorine Sanitizer. L. R. BACON, A. L. SOTIER and A. A. ROTH. *J. Milk Tech.*, 1953, **16**, 61.

An organic chlorine compound—1.3 dichloro-5, 5-dimethylhydantoin—containing 16 per cent available chlorine, was found to give results in field trials comparable with those with sodium hypochlorite. When used on farm utensils the counts of heat-resistant bacteria in milk were very low.

Studies on the Use of Permanent Milk Pipe Lines in Dairy Barns. II. Milk quality as Affected by Types of Installation and Sanitation Procedures. W. A. ALEXANDER, W. O. NELSON and E. E. ORMISTON. *J. Dairy Sci.*, 1953, **36**, 303.

After trials using fixed pipe lines of stainless steel or glass, the authors report that milk handled by methods similar to those outlined in the previous abstract, is equal in bacteriological quality to that produced and handled by conventional methods. They point out, however, that improperly cleansed pipe lines may add large numbers of thermoduric

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and other organisms to the milk. In cases where heavy contamination had occurred, it was easy to restore pipe lines to their proper condition by resuming correct rinsing, washing and disinfection *in situ*.

Suggested Method for the Installation and Cleaning of Cleaned in Place Sanitary Milk Pipe Lines for Use in Milk and Milk Products Plants. *J. Milk Tech.*, 1953, 16, 77.

In recent years there has been a tendency to clean milk pipe lines in position, with only occasional dismantling. The benefits are obvious and it now appears that, with certain precautions in construction, erection and sterilization, success may be achieved. Three official bodies in the U.S.A. have collaborated to produce "suggested methods and procedure".

A.T.R.M.

POULTRY HUSBANDRY

Marketing

Two recent publications by the United States Department of Agriculture are of topical interest in connection with the decontrol of eggs in this country and the new problems which will, in consequence, arise. *Circular No. 911* (published in October 1952) is entitled "A Study of the Washing and Storage of Dirty Shell Eggs" by Orme J. Kahlenberg *et. al*. One of the main contentions is that dirty eggs should be washed and dried and sold as soon as possible to consumers or broken out promptly, for the storage of such eggs leads to heavy losses. While both washed and unwashed eggs rapidly declined in quality in storage—particularly after the second month—the decline was much greater in the washed eggs. Oil processing retarded the deterioration rate in all eggs, and it is interesting to note that the bacteria counts in the oiled eggs were lower than in un-oiled clean eggs. The authors considered that in many instances washing machines were not being operated in accordance with manufacturers' instructions, and so the rate of deterioration in washed eggs was accelerated. The opinions expressed by the writers of this booklet indicate clearly that if storage of eggs is contemplated in this country on a large scale as an aid to orderly marketing, it must be confined to clean unwashed eggs if an excessive number of rots and consequent heavy losses are to be avoided.

Dealing with another aspect of oiled eggs, is *Circular No. 902* (published in April 1952) on "Consumer Acceptance of Thermostabilized, Oil-Processed, and Natural Shell Eggs" by K. M. Hayes, H. E. Gorseline and R. E. Moser, Jr. The findings of these workers are of special interest in connection with oiled eggs, in view of the probability of this method of treatment being extensively used in this country in the future. Apparently the untreated eggs could be detected by the majority of consumers taking part in the study. The same rating was given by

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consumers to thermostabilized and oil-processed eggs, but those treated at 136° F. were preferred to those treated at 130° F. One point of interest was the change in the whipping qualities of the thermostabilized eggs ; these qualities were less favourable when compared with the untreated eggs.

Disease

On another aspect relating to eggs—on this occasion, hatching eggs—the treatment adopted against *Salmonella* infection is discussed in an article entitled “ The Disinfection, prior to Incubation, of Hens Eggs contaminated with *Salmonella pullorum* ” by J. E. Lancaster, R. F. Gordon, and J. Tucker (*Brit. vet. J.*, 1952, **108**, 418-31). The authors give an account of several disinfectant solutions which were efficient in the removal of *S. pullorum* from artificially infected clean and dirty eggs. The solutions, when used at double the strength recommended, had no apparent adverse effect on hatchability. The disinfectants were not effective in reducing the incidence of rots during the storage of table eggs.

Breeding

Another subject of topical interest is dealt with in the article “A Comparative Analysis of Pure-bred and Cross-bred Poultry” by S. C. King and J. H. Bruckner (*Poult. Sci.*, 1952, **31**, 1030-6). The authors discuss the performance of the pure-bred and cross-bred half sib progeny of B.P. Rocks and R.I.R's. A highly significant improvement was observed in the cross-breds, so far as growth rate, age at first egg and egg production were concerned. The authors, however, draw attention to a possible sex-linked effect for egg production since the Barred Cross was consistently superior to other matings used. The importance of this point in testing strains in reciprocal cross-matings to find a combination which “ nicks ” well, is emphasized. Similar findings are recorded in a paper on “ Cross-breeding for Egg Production ” by E. W. Glazener, R. E. Constock, W. L. Blow, R. S. Dearstyne and C. H. Bostein (*ibid.*, 1952, **31**, 1078-83).

Nutrition

It has been widely assumed that antibiotics are effective in stimulating growth only if some unknown infection is present, and it has been further assumed that this unknown infection rapidly builds up in housing where chickens have been kept for some time. Some doubt is cast on these beliefs in the conclusions reached in an article on “ The Effects of Penicillin Supplements on the Growth of Chicks ” by J. O. L. King and E. G. White (*Vet. Rec.*, 1953, **65**, 149-52). In an experiment conducted by the authors, chicks housed in old buildings previously used for poultry did not show a response to the antibiotic, and there was no significant weight differences between the control group and the treated group. These results are the opposite of the findings of S. K. Kon and his associates. King and White comment on the marked differences

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within each group and conclude that young chicks do not always benefit from a penicillin supplement, and stress that further work is needed to justify the popular belief that an unknown "infection" exists in many buildings which house poultry for some years, or that the feeding of penicillin is justified under practical conditions of poultry-rearing.

Of allied interest is a paper on "Fishmeal and the Response of Chicks to Antibiotics" by H. D. Branion and D. C. Hill (*Poult. Sci.*, 1953, **32**, 151-8). In this paper the writers found that for maximum response to an antibiotic (it will be noted that improved growth resulted) the presence of fishmeal was necessary, but that its presence lowers the *percentage* response to the antibiotic. The authors suggest that the use of the antibiotic may result in the synthesis in the gut or tissues of some unidentified factor present in fishmeal, but that such synthesis is not adequate. It is also surmised that more than one unknown factor may be present in fishmeal.

Discussing "Clam Shells, Limestone and Oyster Shells as Sources of Calcium in the Rations of Laying Hens," T. M. MacIntyre and M. H. Jenkins (*Sci. Agric.*, 1952, **32**, 645-50) describe the value of these different materials in supplying calcium for egg shell formation. They conclude that the several sources of calcium used did not lead to any comparative difference in egg production, feed consumption or maintenance of body weight. Egg shells of superior quality, however, were produced from birds fed clam shells or oyster shells together with insoluble grit, when compared with the quality of egg shells from birds fed oyster shells or limestone alone.

Management

On management problems, a paper on "Maintaining Winter Egg Production by the Use of Dim Red Light" by C. S. Platt (*Poult. Sci.*, 1953, **32**, 143-5) is of interest. The author found that red bulbs of 10-watt capacity, used from 8 p.m. to 4 a.m., were as effective as all-night light and equally as satisfactory in promoting winter egg production as the more customary practice of using ordinary white light to ensure a 14-hour light day.

Built-up litter has been claimed to reduce the incidence of coccidiosis. This claim is not substantiated in a report on "The Effect of Built-Up Litter on the Parasite Ova and Oocysts of Poultry" by F. R. Koutz (*ibid.*, 313-20). The experiments described demonstrated that the parasite ova of *Ascaridia galli*, *Heterakis gallinae* and *Capillaria retusa* in built-up litter were not destroyed.

R.C.

MYCOLOGY

Brown Rot

The Effect of Age of Wound and of Weather on the Susceptibility of Apple Injuries to Infection by the Brown Rot Fungus. R. J. W. BYRDE. *Ann. Rep. Long Ashton Res. Sta.*, 1951, 128-31.

Tests on samples of Laxton Superb apples, freshly picked in late summer, showed that wounds became readily infected if inoculated with the Brown Rot fungus as soon as they were made. There was a decrease in the number of successful inoculations when spores were applied to wounds made twenty-four hours earlier. On fruit exposed to natural infection on the trees, there was more infection in early September, when mean temperature was approximately 60.6° F., than in late September when the mean temperature was approximately 55.7° F.

Tests of Eradicant Fungicides against Brown Rot. I. R. J. W. BYRDE and A. H. FIELDING. *Ann. Rep. Long Ashton Res. Sta.*, 1951, 131-3.

In tests on detached mummified apples in April the diphenyl mercury salt of 2:2'-naphthyl methane-3:3'-disulphonic acid was as effective as phenyl mercury chloride, but even the lowest effective concentrations of both are uneconomic. Pentachlorophenol was as effective as its sodium salt at concentrations from 0.05 to 0.8 per cent, and both these materials are cheaper than the mercury compounds.

Experiments on the Control of Brown Rot of Apples and Plums.
II. Winter Spraying Trials. R. J. W. BYRDE. *J. hort. Sci.*, 1952, 27, 192-200.

Several eradican fungicides, including organo mercurials, arsenites and substituted phenols and cresols, caused considerable inhibition of sporing pustules when applied to detached mummified plums infected with *Sclerotinia fructigena*. In field trials, phenyl mercury chloride applied at 0.2 or 0.3 per cent early in March reduced sporulation on infected apple and plum fruit by 90 per cent, but did not diminish significantly the amount of infection in the succeeding crop. This is due to the rapid multiplication of the fungus from the remaining pustules.

Experiments on the Control of Brown Rot of Apples and Plums.
III. Summer Spraying Trials. R. J. W. BYRDE. *J. hort. Sci.*, 1952, 27, 237-44.

Sprays containing phenyl mercury chloride, dichloronaphthoquinone, and trichloromethyltetrahydrophthalimide (S.R. 406), gave no significant control of the disease on plums in 1950. This failure after the promising results of the previous year may be due to the heavier July rainfall in 1950. On Laxton's Superb apple, two applications of 0.05 per cent 2:3 dichloro-1:4 naphthoquinone reduced infection from 5.4 to 0.2 per cent. Phenyl mercury chloride produced no reduction. Both materials caused some damage to the fruit, especially plums.

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Observations on Brown Rot (*Sclerotinia fructigena*) of Apples in Relation to Injury caused by Earwigs (*Forficular auricularia*).

H. E. CROXALL, C. A. COLLINGWOOD and J. E. E. JENKINS. *Ann. appl. Biol.*, 1951, **38**, 833-43.

In the West Midlands from 1947 to 1950, brown rot on Cox's Orange Pippin and Laxton's Superb apples was often associated with small shallow holes in the fruit. Experiments showed that earwigs could produce this type of injury. Bands of sacking soaked in benzene hexachloride placed round trees caught many earwigs, and significantly reduced the amount of brown rot. A survey of fruit in packing stations showed close correlation between the amounts of brown rot and earwig injury. Earwig injury occurred mainly in fruit from grass orchards and not in those from arable plantations.

H.E.C.

PROVINCIAL NOTE

THE MARGINAL LANDS AND HILL PASTURES OF THE NORTHERN PROVINCE

A. BLENKINSOP

National Agricultural Advisory Service, Northern Province

In 1952, there were some 900,000 acres classified as rough grazings—about 33 per cent of the total agricultural area—in the Northern Province. It is doubtful if all the open moors were included in the returns, but as this proportion corresponds roughly with that above the 750 foot contour, we might regard this as a sort of datum line for this short descriptive article.

The following figures for the four individual counties are given as pertinent in this respect.

County	Percentage Rough Grazing in 1952	Percentage Reduction in Rough Grazing since 1939	Percentage of County Area above 750 ft. (approx.)
Northumberland	44	5	25
Durham	16	46	25
Cumberland	34	30	37
Westmorland	36	46	37

Whilst much has been done already to bring relatively unproductive acres under control, it is clear that there is still room for improvement

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on these hill lands and those in other provinces. But observation shows, and statistics prove, that many of these acres have been ploughed out before, and it is apparent that any new campaign will need study and planning from many angles to prevent further relapses.

The uplands in this province can be conveniently divided into three main blocks: the Lake District; the Alston block comprising the northern part of the Pennines between Stainmore and the Tyne Gap; and Cheviot and the Border Hills. These regions differ from each other in geology and ecology, and the fact that each has its own native breed of sheep is sufficient proof that these factors have some agricultural significance.

Geology

The Lake District rocks comprise three roughly rectangular divisions: the Borrowdale volcanic series over the central belt, the Skiddaw slate mountains to the north, and the Silurian slates, grits and shales in the south. Granite intrusions have been exposed on the west in Ennerdale and Eskdale and on the east at Shap.

The Alston block, which dips gently eastward, exhibits the Yoredale succession of limestone, shale and sandstone. Although the limestone outcrops are prominent in the sides of the valleys, they are relatively thin and there is, in consequence, a scarcity of limestone pastures except around Alston. Along the northern and eastern slopes these are succeeded in turn by sandstones of the Millstone Grit and Coal Measures.

The Cheviot block consists of the granite boss of Cheviot surrounded by red andesite lavas of Devonian age. These latter rocks, being of homogeneous basic volcanic material, have weathered evenly to form a well-rounded, hilly topography with free, open drainage and fairly good soils supporting a useful close *nardus fescue* sward. The higher granite area is, by contrast, wet and undrained and covered by deep peat hags. The hills to the south-west of Cheviot are Lower Carboniferous rocks which have no counterpart in the exposed part of the Alston Block. The higher ground is composed of Cemenstone and Fell Sandstone, the latter predominating in the Peel Fell and Carter Fell region, and the former on the Bewcastle Fells to the east. A large area (to which special reference will be made later) to the north of the Roman Wall between the North Tyne and the Bewcastle Fells, consists mainly of rocks of the Scremerston Coal group. The Fell Sandstones are hard massive rocks which give the bold craggy escarpments so characteristic of Northumberland. The Cemenstone and Scremerston rocks—comprising thick beds of shale and soft sandstone with thin ribs of impure limestone—are easily weathered, however, forming a smooth undulating type of terrain. To the south-east of the Cheviot Old Red Sandstone mass, and separated from it by a trough of Cemenstone, the Fell Sandstone forms a conspicuous range of craggy hills which reach their best development in the neighbourhood of Rothbury and Chillingham.

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The soils in all these hill areas have been considerably influenced by glacial action. In the Lake District the radial valleys were scoured by ice, and rock debris was carried down to the lower ground. On the Cheviots and the Alston Block this effect was apparently less violent, and although some boulder clay deposits are found on flat ground at high altitudes, they are mainly concentrated on the lower slopes of the valleys. In the Alston area the drift is very much thicker on the slopes facing east. Here the gradients are long and smooth, and the land wet and infested with rushes. On the western facing slopes the ground falls in terraces over a succession of limestone strata on which the thin, well-drained soils provide close swards of the fescue type.

Wherever the conditions of soil or topography have favoured poor drainage, thick deposits of peat have been formed. Pollen grain analyses of the peats have enabled ecologists to reveal a long story of vegetation changes on these hills, on which (probably before the introduction of sheep in the Middle Ages) there were extensive forests of oak, birch and alder up to about 1,400 feet. It is universally agreed by all the workers who have studied them that these wet peats are now slowly shrinking—mainly through erosion. The drier, non-fibrous peats under heather on the sandstone soils are more acid than the wet sphagnum peats, and need more generous fertilizer treatment when being reclaimed.

Vegetation

A reference to the map of the Grassland Survey of England and Wales carried out by Stapleton and Davies in 1939-40, shows that the separate vegetative types are associated with geology and topography, although there is not a close correlation between altitude and rainfall. In general, the cotton grass type is found on the high flat plateaux where the rainfall is highest and where the parent material is boulder clay or soft shale. The thick deposits of peat limit the facilities for the study of pedogenic processes, but it would seem that podsolization is not an obvious one. The *nardus* fescue combination is best exemplified on the well-drained slopes of the Old Red Sandstone volcanic soils surrounding Cheviot. Here, as also in parts of the Lake District and on some of the valley slopes in the Alston Block, the profiles are of the Brown Earth type. On the driest soils of all—that is, on the Millstone Grit, the Coal Measure sandstones and the Fell Sandstone—the heath type of vegetation is seen to perfection. Around Blanchland and Muggleswick in west Durham and Rothbury in Northumberland, the wide stretches of undiluted heather moor provide an impressive picture in the months of August and September. The soils are thin, light, and porous with a black amorphous humus layer in the A₀ horizon, and although situated on the drier side of the Pennines, they are the most highly podsolized in the province. Apart from the mixed fell type of vegetation associated with the steep rocky terrain of the Lake District, the remaining major types are the *molinia* on the Border Hills. The higher ground contains a fair admixture of *nardus* and other species, but the lower ground to the

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south constitutes one of the largest and purest molinia areas in the whole country.

Improving the Land

Lead has been exploited in the neighbourhood of Alston since Roman times, and a few seams of coal are being worked today. In the upper North Tyne valley, afforestation on a large scale has been in operation since 1926 ; some 45,000 acres out of the 75,000 acquired for the purpose, have been planted, mainly with coniferous trees. Some open ditch drainage work has been carried out mainly on the Border Hills, but apart from the burning of heather, the "management" of these moors is left to the half million sheep which they support. Along the lower slopes of the moors, many improvement schemes have been, and are being, undertaken with the help of Ministry grants. The rate of progress of reclamation is slow, however, in relation to the magnitude of the problem and the urgent need for more productive acres. One big obstacle is the existence of extensive areas of land held "in common," especially in the Lake District and on the Pennines. Attempts are being made to enclose and apportion some of these areas through the existing machinery for this purpose, but, so far, little headway has been made.

In theory, the requisites for permanent improvement are straightforward ; in practice, the problem is beset with many serious difficulties. The single objective is to raise the level of the phosphate status of the soil to a reasonable level, and to keep it there. The factors depressing this level are summed up in the expression "phosphate fixation" and embrace low pH, low temperature, lack of inorganic nitrogen compounds and lack of aeration. This improvement—as can be seen on any of the successful marginal land schemes up and down the country—is effected by drainage, ploughing up, liming and application of phosphate fertilizers. Drainage alone will go far to convert a wet cotton grass or molinia to a heather or even a *nardus fescue* sward.

The effects of altitude, with its adverse concomitants of low temperature and exposure, are apt to be over-estimated when one sees, as in Upper Weardale, the productive leys and even soft fruits growing at over 1,500 feet. One can, in fact, merely contrast the existing conditions between, say, the Alston Nenthead district and the molinia-covered moors north of Haltwhistle. In the former, much of the land up to 1,600 feet has been enclosed and a settled agriculture established for centuries, based on small family farms of 50 to 60 acres of good grassland. Some of the fields reach 1,900 feet, and the small farm appropriately called Grasshill (1,980 feet) in Upper Teesdale is the highest habitation in the British Isles. In the area north of Haltwhistle there may be well over 50 square miles of potentially useful agricultural land mostly below the 1,000 foot contour, little better than a waste of molinia moor providing an inadequate pasturage for about one sheep to 3 or 4 acres. Lead and coal (and, perhaps, Scottish marauders) have been more responsible

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for this strange contrast in development than altitude and climate, but here is a legacy of a "forgotten" land which may someday be worth exploiting. For the production of virus-free strains of such crops as potatoes, sugar beet, strawberries or raspberries the situation is ideal, and there is no reason why small patches, accessible from the very few roads, should not be cultivated for trials in this direction. In the kitchen-garden of a hill farm in south-west Northumberland, a strain of strawberries has been left virus-free for at least 50 years.

On the higher fells beyond the range of the marginal schemes, little more than drainage by open channels is feasible at the present stage. In so far as this will tend to promote a heath type of vegetation, the change from *molinia* or cotton grass will constitute an improvement in the stock-carrying capacity of the moors. The generally accepted view that heather is the most nutritive of the individual moorland species for sheep, is supported by Brynmor Thomas, who has done very valuable work on this subject. Liveweight increases of about 85 lb. per acre—compared with 50 lb. on the untreated plot on Tree Field at Cockle Park—recorded by Peart on a heather sward at 1,100 feet in Weardale confirm this view. The corresponding figure for the slag-treated plot at Cockle Park is 170 lb. per acre. It might be mentioned in this connection that "pinning," due to cobalt deficiency, occurs sporadically over most of the "grass" moors but is relatively rare on the true heather moors.

Subsequent improvement entails the use of lime and phosphate fertilizers at frequent intervals, and the possibilities in this direction are only just being explored. Tentative experiments using small dressings of ground limestone and superphosphate—comparable with amounts which might be spread from an aeroplane—have been started. The immediate effect of phosphate on the moors is always to attract sheep to eat the herbage (other than heather) down to the bare earth; the effect of lime is similar, especially with cattle.

The existing assisted schemes should result in a permanent assimilation of land on the fringe of the hill country. But the lesson to be learnt from the Alston settlements is that occupation and habitation would be necessary to maintain higher level of production on the open spaces further afield.

How far can timber replace lead in assuming the role of foster parent to agriculture, and ensure the continuity of effort needed on these fells? The Report of the 1944 Committee on Hill Sheep Farming in England and Wales did not overlook this aspect of the problem, and it can be presumed that the Forestry Commission is fully alive to the opportunities on that part of its own property not needed for timber. The outlook for the rehabilitation of the remainder of the upland country is not encouraging, though we have our full share of pioneers in hill pasture improvements who are doing excellent work.

AGRICULTURAL RESEARCH COUNCIL

QUANTITATIVE INHERITANCE

Edited by

**E. C. R. REEVE, B.A., Ph.D.,
and Professor C. H. WADDINGTON, Sc.D., F.R.S.**

The papers reproduced in this volume were read at a colloquium held in Edinburgh in 1950. They include a theoretical discussion by Professor Sewall Wright of Chicago, and descriptions of several extensive experiments by Professor Mather and by members of the Agricultural Research Council's staff at the Institute of Animal Genetics. Among the purposes of the colloquium were the discussion of the validity of the basic biological assumption on which the statistical theory is based, and the attempt to decide what new theoretical developments are most urgently required.

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